Stantec

Stantec Consulting Services Inc.
10200 Alliance Road, Suite 300, Cincinnati, Ohio 45242

January 18, 2024
File: 175578395

Attention: Justin Gardner, PE
Ohio Department of Transportation, District 9
650 Eastern Avenue
Chillicothe, Ohio 45601

Reference: JAC-35-15.36 Landslide
Report of Landslide Exploration (Final)
Jackson County, Ohio

Dear Mr. Gardner,

Stantec Consulting Services Inc. (Stantec) has completed the Report of Landslide Exploration for the landslide near mileage 15.36 of US Route 35 in Jackson County, Ohio. The enclosed report contains a brief description of the site, geologic conditions encountered, the scope of work performed, and geotechnical recommendations for the proposed landslide remediation.

Regards,

Stantec Consulting Services Inc.

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Attachment: Report of Landslide Exploration (Final)

STATE OF OHIO
ERIC M. KISTNER
E-65507
01/18/24
REGISTERED
PROFESSIONAL ENGINEER

Stantec

Report of Landslide Exploration (Final)

JAC-35-15.36 Landslide
PID No. 116242

Jackson County, Ohio

January 18, 2024

Prepared for:

Ohio Department of Transportation District 9

Prepared by:

Stantec Consulting Services Inc.

Cincinnati, Ohio

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Executive Summary

A landslide is located along approximately 70 feet of United States Route (US) 35 near straight line mileage 15.36 southeast of Jackson, Ohio in Jackson County. The landslide is impacting the westbound shoulder of US 35 with the scarp affecting the guardrail and edge of pavement. The Ohio Department of Transportation (ODOT) is planning to repair and stabilize the roadway where the landslide is located. Stantec Consulting Services Inc. (Stantec) was contracted by ODOT to perform the geotechnical exploration and design for this remediation.

ODOT previously repaired a landslide at this same location in the mid-1970s by removing the failed material, excavating a keyway into stable soil, installing a granular drainage layer on the excavated slope, and rebuilding the embankment to its original 2:1 horizontal to vertical slope (JAC-35-14.88; PID 012599). Four borings were advanced prior to this repair, with two located on the existing shoulder of US 35 and two located at the toe of the slope. The boring logs show overburden soil that classified as A-3a, A-4a, A-4b, A-6a, and A-7-6. Bedrock ranged from about 10 to 20 feet deep in the borings. Approximately 5 feet of rock core was obtained from each boring and was described as “siltshale” and “clayshale”.

One additional boring (B-001-0-23) was advanced by Central Star through the existing paved shoulder to supplement the data from the repair described above. The surface material encountered consisted of 10 inches of asphalt pavement. Granular soil described as light brown to gray coarse and fine sand (A-3a) was encountered below the asphalt to a depth of 7.5 feet. The sand was described as medium dense to dense and damp to moist. Fine-grained soil described as gray sandy silt (A-4a) was encountered from 7.5 to 20.0 feet in depth. The soil was described as stiff to very stiff and damp to moist. Decomposed to severely weathered dark gray shale was then encountered from a depth of 20.0 to 25.6 feet. This bedrock was sampled with the split spoon sampler due to weathering conditions. Competent shale bedrock was encountered at a depth of 25.6 to 28.9 feet then again at a depth of 32.7 to 40.8 feet. The shale was described as dark gray, severely to moderately weathered, highly to moderately fractured, and argillaceous. Siltstone was encountered in the boring at a depth of 28.9 to 32.7 feet. The siltstone was described as gray, severely to moderately weathered, moderately fractured, and argillaceous. Groundwater was encountered during drilling at a depth of 24.0 feet.

It is recommended that a drilled shaft wall be constructed along the north shoulder of US 35 in the affected areas of SLM 15.36 at an approximate offset of 60 feet east of the centerline of US 35. The retaining wall system for the site may consist of 3-foot diameter drilled shafts at 5.75-foot center-to-center spacing reinforced with W24x68 steel sections or 2.5-foot diameter drilled shafts at 4.75-foot center-to-center spacing reinforced with W21x55 steel sections. The reinforced drilled shafts should be embedded a minimum of 10 feet into bedrock. To protect against loss of material through the drilled shaft wall, unreinforced plug drilled shafts are recommended to be installed between and at an offset behind the reinforced drilled shafts. The unreinforced plug shafts should have the same diameter as the selected retaining wall system and extend to the top of competent bedrock.

1.0 INTRODUCTION

A landslide is located along approximately 70 feet of United States Route (US) 35 near straight line mileage 15.36 southeast of Jackson, Ohio in Jackson County. The landslide is impacting the westbound shoulder of US 35 with the scarp affecting the guardrail and edge of pavement. The Ohio Department of Transportation (ODOT) is planning to repair and stabilize the roadway where the landslide is located. Stantec Consulting Services Inc. (Stantec) was contracted by ODOT to perform a geotechnical exploration and remediation design. Figure 1 and Appendix A show the site vicinity.

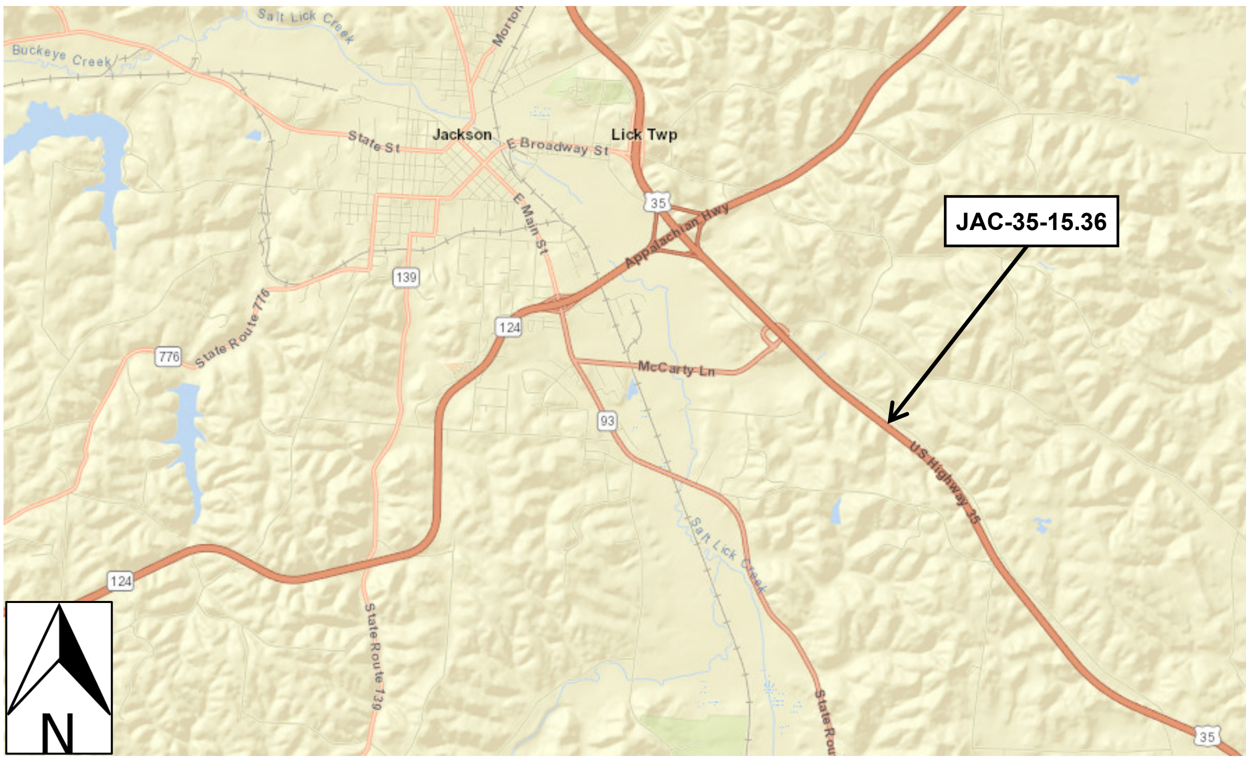


Figure 1. Site Vicinity
(Portion of ODOT Transportation Information Mapping System (TIMS), 2023)

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 GENERAL

The Physiographic Regions of Ohio Map (Ohio Department of Natural Resources (ODNR), 1998) indicates that the project site is located within the Ironton Plateau physiographic region. The region is characterized as a dissected plateau containing more coarser grained coal-bearing rock formations than other regions in of the Allegheny Plateau. The geology of the Ironton Plateau is described as Pleistocene-age Minford Clay with silt-loam and channery colluvium. Typical bedrock of the region is Pennsylvanian-age sandstones, siltstones, shales, and economically important coal seams. The region has moderately high relief (generally 300 feet) with elevations of 515 to 1,060 feet.

2.2 SOIL GEOLOGY

According to the Quaternary Geology of Ohio map (ODNR, 1999), the project site is underlain by Cenozoic colluvium derived from local bedrock in unglaciated areas of Ohio. This includes scattered areas of residuum, weathered material, landslides, and bedrock outcrops. The soil survey (Web Soil Survey of Jackson County, Ohio, United States Department of Agriculture (USDA), 2023) indicates that the project site is underlain primarily by soils from the Orrville silt loam and Shelocta-Latham complexes. The typical profile of the Orrville complex is 8 to 16 inches of silt loam, 21 inches of loam, and 43 inches of stratified gravelly loamy sand to silt loam. The soils are somewhat poorly drained with a moderately high to high capacity to transmit water. The typical profile of the Shelocta-Latham complex is 11 inches of silt loam underlain by 31 to 57 inches of channery silty clay loam. The soils are well drained with a moderately high to high capacity to transmit water.

2.3 BEDROCK GEOLOGY

Bedrock mapping (Ohio Geology Interactive Map [ODNR, 2023]) and Descriptions of Geologic Map Units (ODNR, 2011) indicates that the overburden soils at the project site are underlain primarily by sedimentary bedrock from the Allegheny and Pottsville Groups, Undivided from the Pennsylvanian age. The primary types of rock in this group are shale, siltstone, and underclay. The shale is described as black, gray, and olive in color and clayey to silty. The siltstone is described as gray or greenish gray and olive in color, clayey to sandy, and thin to medium bedded. The underclay is described a grey to olive in color, generally less than 3 feet in thickness, clayey to silty, with underlying coal beds. Bituminous coal is also found in the Allegheny and Pottsville Groups.

According to the Ohio Oil and Gas Well Viewer map (ODNR, 2023), there is one active gas well located within 2 miles of the project location. The well summary shows bedrock formations beginning at a top depth of 206 feet.

According to the Ohio Mine Locator (ODNR, 2023), there are no mines within the project footprint. There are multiple historic surface mines located two miles east and south of the site. There are also abandoned underground coal mines located 1.5 miles northwest of the site. The Karst Interactive Map (ODNR, 2023) indicates there are no known karst features in Jackson County.

2.4 HYDROLOGY

Surface water is assumed to drain to the northwest towards Sand Run approximately 0.5 miles away from the site. Sand Run flows to the west into Salt Lick Creek approximately 1.7 miles south of Jackson, Ohio. Salt Lick Creek flows north to Rock Run Creek approximately 2 miles northwest of Jackson, Ohio. Rock Run Creek joins Salt Creek then the Scioto River approximately 14.5 miles northwest of Jackson, Ohio. The Scioto River then flows into the Ohio River near Portsmouth, Ohio.

2.5 HYDROGEOLOGY

According to the Groundwater Resources of Jackson and Vinton Counties map (ODNR, 1985), the project site is in an area where wells yield less than three gallons per minute. Bedrock consisting of layers of sandstone, shale, underclay, coal, and limestone cause most drilled wells to yield less than 2 gallons per minute.

A search was performed using the ODNR Ohio Water Wells Map (2023) to determine if any water wells are located near the project site. According to the map, eight water wells have been drilled within one mile of the project footprint. Sandstone and shale are the primary aquifer types for all eight wells. The well logs indicate a bedrock depth ranging from 5 to 32 feet. The logs also indicate highly variable static water depths, ranging from 10 to 87 feet.

2.6 SEISMIC

Overall, Ohio has a relatively limited amount of seismic activity. According to the Ohio Earthquake Epicenter Map (ODNR, 2023), one earthquake epicenter was recorded in June 2022 approximately 0.65 miles south of the project site. A magnitude of 0.2 was recorded for this earthquake. No other earthquakes were recorded within 10 miles of the site. The available data reviewed included events that occurred in Ohio from 1804 to present day.

2.7 SITE RECONNAISSANCE

A Stantec and ODOT representative visited the site on February 7, 2023. The landslide measured about 70 feet long along the westbound shoulder. Scarping was observed below the guardrail of US 35. The guardrail was also observed to be deflecting away from the roadway due to slope movement. Orange traffic barrels had been placed in the emergency lane to prevent traffic from stopping in the area of the landslide. Sloughing was also observed down slope of the roadway. It appeared that the roadway had been constructed using cut-and-fill methods along a hillside, cutting from higher on the hillside and filling lower on the hillside to create the road. The land surrounding the project site can be described as rural and residential.

3.0 EXPLORATION

3.1 HISTORIC EXPLORATION PROGRAMS

The ODOT Traffic Information Management System (TIMS) provides documentation for a landslide exploration project that was performed in the mid-1970s at the same location by removing the failed material, excavating a keyway into stable soil, installing a granular drainage layer on the excavated slope, and rebuilding the embankment to its original 2:1 horizontal to vertical slope (JAC-35-14.88; PID 012599). Four borings were advanced prior to this repair, with two located on the existing shoulder of US 35 and two located at the toe of the slope. The boring logs show overburden soil that classified as A-3a, A-4a, A-4b, A-6a, and A-7-6. Bedrock ranged from about 10 to 20 feet deep in the borings. Approximately 5 feet of rock core was obtained from each boring and was described as “siltshale” and “clayshale”. Data from this exploration are included in the drawings provided in Appendix A.

3.2 PROJECT EXPLORATION PROGRAM

One boring was advanced by Central Star Drilling to supplement subsurface data associated with the landslide that was collected during the previous landslide repair described in Section 3.1. A summary of the boring is shown in Table 1. The boring location and log is provided with the geotechnical drawings in Appendix A.

Table 1. Boring Summary

Boring No.	Centerline	Offset (feet)	Ground Surface Elevation (feet)	Bedrock Elevation (feet)	Bottom of Boring Elevation (feet)
B-001-0-23	US 35	49.7 Lt.	711.9	691.9	671.1

The boring was advanced in accordance with the ODOT Specifications for Geotechnical Explorations (SGE). The boring was performed with a Diedrich D50 track-mounted drill rig using 3¼-inch inside diameter (ID) hollow stem augers to advance the borings through soil. Standard Penetration Test (SPT) sampling was performed continuously until bedrock was encountered. Shelby tubes were used to obtain undisturbed samples in cohesive soil at depths of 5.5 to 7.5 feet and 13.5 to 15.5 feet according to ASTM D 1587.The energy ratio (ER) of the automatic hammer and drill rod system was measured to be 86.5 percent March 14, 2022.

The SPT is performed by advancing a split-spoon sampler, 18 inches in length, with a 140-pound automatic hammer dropping 30 inches at select depth intervals in the boring. The number of hammer blows needed to advance the sampler each 6-inch increment is recorded. The blow count from the first 6-inch increment is discarded due to ground disturbance at the bottom of the boring. The sum of the blow counts from the last two 6-inch increments is called the field N-value (N_{field}). The field N-value is corrected to an equivalent rod energy ratio of 60 percent (N_{60}) according to the equation below.

$$N_{60} = N_{field}\left(\frac{ER}{60}\right)$$

The depths and elevations of the SPTs with the corresponding N_{60}-values are shown on the boring log in Appendix A.

Upon encountering relatively competent bedrock, rock coring was performed in the boring using NQ2-size equipment. Recovery, core loss, and rock quality designation (RQD) values were recorded as percentages for each coring run. The recovery is a measurement of the core sample obtained from a core run. The loss is the difference between the core run and the recovery. The RQD is measured by dividing the sum of all pieces of intact rock core longer than four inches in a run by the total length of the core run. These values are shown on the boring log provided in Appendix A.

The materials encountered were logged by a geotechnical engineer, with attention given to soil type, consistency, and moisture content. The boring was checked for the presence of groundwater during drilling and at its conclusion with the depth of water recorded. The boring was sealed according the ODOT SGE and capped with asphalt cold patch.

Samples obtained from the boring was returned to a geotechnical laboratory for visual classification and tested for water content. Engineering classification testing was performed on samples reflecting each of the main soil horizons. The engineering classification tests conducted on the samples were sieve and hydrometer analysis (ASTM D 422) and Atterberg limits (ASTM D 4318). The samples were classified according to the ODOT classification method. Two undisturbed Shelby tube samples were subjected to unconfined compressive strength tests (ASTM D 2166) and engineering classification tests. Point load index testing (ASTM D 5731) was completed to approximate the compressive strength of bedrock. The results of laboratory testing are included in Appendix A.

4.0 RESULTS

Boring B-001-0-23 was advanced through the emergency lane of westbound US 35. The surface material encountered consisted of 10 inches of asphalt pavement. Granular soil described as light brown to gray coarse and fine sand (A-3a) was encountered below the asphalt to a depth of 7.5 feet. The sand was described as medium dense to dense (N_{60} values range from 19 to 35 blows per foot with an average of 27 blows per foot) and damp to moist (natural moisture contents range from 8 to 14 percent with an average of 11 percent). One unconfined strength of soil test completed in this material resulted in an unconfined compressive strength of 0.15 tons per square foot (tsf) and a wet unit weight of 125 pounds per cubic foot (pcf).

Fine-grained soil described as gray sandy silt (A-4a) was encountered from 7.5 to 20.0 feet in depth. The soil was described as stiff to very stiff (N_{60} values range from 13 to 22 blows per foot with an average of 15 blows per foot) and damp to moist (natural moisture contents range from 14 to 18 percent with an average of 16 percent). The liquid limit of this material ranges from 24 to 27 with an average of 25, and the plastic limit ranges from 16 to 19 with an average of 18. One unconfined strength of soil test completed in this material resulted in an unconfined compressive strength of 0.81 tsf and a wet unit weight of 133 pcf.

Decomposed to severely weathered dark gray shale was then encountered from a depth of 20.0 to 25.6 feet. This bedrock was split spoon sampled due to the soil-like consistency of the material.

Competent shale bedrock was encountered at a depth of 25.6 to 28.9 feet then again at a depth of 32.7 to 40.8 feet. The shale was described as dark gray, severely to moderately weathered, highly to moderately fractured, and argillaceous. Point load index testing was completed on shale bedrock and resulted in an average index value of 64, which corresponds to an unconfined compressive strength value of approximately 766 pounds per square inch (psi) using methods outlined in section 406.2 of the ODOT Geotechnical Design Manual. Siltstone was encountered in the boring at a depth of 28.9 to 32.7 feet. The siltstone was described as gray, severely to moderately weathered, moderately fractured, and argillaceous.

Groundwater was encountered during drilling at a depth of 24.0 feet. The boring log, photographs of the rock core are presented in Appendix C. Results from laboratory testing are provided in Appendix A.

5.0 ANALYSES AND RECOMMENDATIONS

5.1 GENERAL

The recommendations that follow are based on the information discussed in this report and the interpretation of the subsurface conditions encountered at the site during our fieldwork. If future design changes are made, Stantec should be notified so that such changes can be reviewed, and the recommendations amended as necessary.

These conclusions and recommendations are based on data and subsurface conditions from the borings advanced during this exploration using the degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. No warranties can be made regarding the continuity of conditions.

5.2 DRILLED SHAFT WALL

The recent landslide was likely caused by low strength soils underlying heavy sands and the saturation of the overburden soils during high precipitation events. ODOT indicated that a drilled shaft wall along the downhill shoulder of US 35 is the current preferred repair. The proposed offset for the drilled shaft wall is 60 feet left of US 35 centerline, approximately 8 feet beyond the existing guardrail.

To model the existing landslide, a cross-section was developed based on the historic exploration, field observations, and information from the new boring. Parameters for each soil layer were chosen to represent existing conditions, including residual shear strengths in soils. The material parameters were chosen based upon correlation of the SPT N-values recorded in the boring logs and published correlations where applicable, and laboratory testing results performed by Stantec.

The friction angle for the granular soil was determined using uncorrected SPT N-values of sand and Table 7-5 in FHWA-NHI-16-072 “Geotechnical Site Characterization”. The average uncorrected SPT N-value of sand is 18, which corresponds to a friction angle of 37 degrees through interpolation. The value was lowered to 30 degrees for a more conservative estimate. The unit weight used in the analysis of 125 pcf was estimated from unconfined compressive strength testing.

For the fine-grained soil, Figure 7-49 in FHWA-NHI-16-072 “Geotechnical Site Characterization” provides a correlation with liquid limit and clay fraction to drained friction angle. Based on an average liquid limit of 25 and an average clay fraction of 26 for the fine-grained soil samples tested, a drained friction angle of 25 degrees was selected based on the figure. The unit weight used in the analysis of 133 pcf was based on laboratory testing of an undisturbed soil sample.

Lateral earth pressure calculations were performed to estimate the lateral loading on the retaining wall exerted by the retained soil. It was assumed that the reinforced drilled shafts would take the full active soil load and unreinforced plug shafts transfer the loading to the reinforced shafts. The lateral earth pressure calculations can be found in Appendix B.

The calculated active soil loads were converted to horizontal distributed pressures for a lateral load analysis using LPile 2019 software. A traffic surcharge live load of 250 pounds per square foot (psf) was applied to the model due to the proximity of the wall to the pavement. It was assumed that the sliding mass may continue to mobilize downslope from the retaining wall. Passive soil resistance for the pile wall was ignored within the approximate depth of slide, which was assumed to be approximately 16.5 feet below grade along the wall based on blow counts shown on the boring log. A bedrock unconfined compressive strength of 73.5 psi, significantly lower than the point load strength testing results, was used in the analysis for the top 5.6 feet of bedrock. This lower strength was selected due to the evidence of highly weathered soil-like bedrock within the top 5.6 feet, as shown by the ability to auger and sample through the material. This compressive strength was determined using methods outlined in FHWA-ICT-17-018 “Modified Standard Penetration Test-based Drilled Shaft Design Method for Weak Rocks” (Stark et.al., 2017). Below the top 5.6 feet, bedrock was modelled with an unconfined compressive strength of 700 psi, which is more reflective of the results of the point load strength testing. The small zone of siltstone encountered while coring bedrock was ignored in the analysis. Methods for determining these bedrock strengths are included in Appendix B.

Steel sections were selected considering a maximum allowable top deflection of approximately 2 inches or less for service loading. The selected shear sections have moment and shear capacities greater than the estimated maximum moment and shear from the lateral load analysis considering strength loading. The resulting retaining wall system consists of 3-foot diameter drilled shafts at 5.75-foot center-to-center spacing reinforced with W24x68 steel sections, embedded 10 feet into bedrock. Top of bedrock elevation along the wall alignment is estimated to range from 688.0 feet at Station 358+00 to 696.0 feet at Station 359+50 based on interpolation and extrapolation of the top of bedrock elevation data shown in Table 2. The top of bedrock elevation at Station 358+75 is estimated to be 690.0 feet. The LPile analysis for this system estimated a maximum deflection of 1.6 inches in the service load state, maximum shear of 154 kips in the strength loading state, and a maximum moment of 508 kip-ft in the strength loading state.

Table 2. Top of Bedrock Elevations at Boring Locations

Station (feet)	Offset (feet)	Bedrock Elevation (feet)
358+00	50 Lt.	690.0
358+60	105 Lt.	680.0
358+74	50 Lt.	692.0
359+00	105 Lt.	682.0
359+50	50 Lt.	699.0

As an alternative to using 3-foot diameter shafts, it was determined that the retaining wall system may also consist of 2.5-foot diameter drilled shafts at 4.75-foot center-to-center spacing reinforced with W21x55 steel sections, embedded 10 feet into bedrock. The LPile analysis for this system estimated a maximum deflection of 2.0 inches in the service load state, maximum shear of 132 kips in the strength loading state, and a maximum moment of 407 kip-ft in the strength loading state. The LPile analyses are provided in Appendix C.

To protect against loss of material through the drilled shaft wall, unreinforced plug drilled shafts are recommended to be installed between and at an offset behind the reinforced drilled shafts. The unreinforced plug shafts should have the same diameter as the selected retaining wall system and extend to the top of competent bedrock.

APPENDIX A
GEOTECHNCIAL DRAWINGS

PROJECT DESCRIPTION

THIS PROJECT, JAC-35-15.36, IS THE EXPLORATION OF A LANDSLIDE GEOHAZARD LOCATED ON THE WESTBOUND EMBANKMENT SLOPE ON US-35 NEAR MILE MARKER 15.06 IN JACKSON COUNTY.

HISTORIC RECORDS

THE ODOT TRAFFIC INFORMATION MANAGEMENT SYSTEM (TIMS) PROVIDES DOCUMENTATION FOR A LANDSLIDE EXPLORATION PROJECT THAT WAS PERFORMED IN THE MID-1970S AT THE SAME LOCATION BY REMOVING THE FAILED MATERIAL, EXCAVATING A KEYWAY INTO STABLE SOIL, INSTALLING A GRANULAR DRAINAGE LAYER ON THE EXCAVATED SLOPE, AND REBUILDING THE EMBANKMENT TO ITS ORIGINAL 2:1 HORIZONTAL TO VERTICAL SLOPE (JAC-35-14.88; PID 012599). FOUR BORINGS WERE ADVANCED PRIOR TO THIS REPAIR, WITH TWO LOCATED ON THE EXISTING SHOULDER OF US 35 AND TWO LOCATED AT THE TOE OF THE SLOPE. THE BORING LOGS SHOW OVERBURDEN SOIL THAT CLASSIFIED AS A-3A, A-4A, A-4B, A-6A, AND A-7-6. BEDROCK RANGED FROM ABOUT 10 TO 20 FEET DEEP IN THE BORINGS. APPROXIMATELY 5 FEET OF ROCK CORE WAS OBTAINED FROM EACH BORING AND WAS DESCRIBED AS "SILTSHALE" AND "CLAYSHALE".

GEOLOGY

THE PROJECT SITE IS LOCATED WITHIN THE IRONTON PLATEAU PHYSIOGRAPHIC REGION. THE REGION IS CHARACTERIZED AS A DISSECTED PLATEAU CONTAINING MORE COARSER GRAINED COAL-BEARING ROCK FORMATIONS THAN OTHER REGIONS IN OF THE ALLEGHENY PLATEAU. THE GEOLOGY OF THE IRONTON PLATEAU IS DESCRIBED AS PLEISTOCENE-AGE MINFORD CLAY WITH SILT-LOAM AND CHANNERY COLLUVIUM. TYPICAL BEDROCK OF THE REGION IS PENNSYLVANIAN-AGE SANDSTONES, SILTSTONES, SHALES, AND ECONOMICALLY IMPORTANT COAL SEAMS. THE REGION HAS MODERATELY HIGH RELIEF (GENERALLY 300 FEET) WITH ELEVATIONS OF 515 TO 1,060 FEET. OVERBURDEN SOILS AT THE PROJECT SITE ARE UNDERLAIN PRIMARILY BY SEDIMENTARY BEDROCK FROM ALLEGHENY AND POTTSVILLE GROUPS, UNDIVIDED FROM THE PENNSYLVANIAN AGE. THE PRIMARY TYPES OF ROCK IN THIS GROUP ARE SHALE, SILTSTONE, AND UNDERCLAY. THE SHALE IS DESCRIBED AS BLACK, GRAY, AND OLIVE IN COLOR AND CLAYEY TO SILTY. THE SILTSTONE IS DESCRIBED AS GRAY OR GREENISH GRAY AND OLIVE IN COLOR, CLAYEY TO SANDY, AND THIN TO MEDIUM BEDDED. THE UNDERCLAY IS DESCRIBED A GREY TO OLIVE IN COLOR, GENERALLY LESS THAN 3 FEET IN THICKNESS, CLAYEY TO SILTY, WITH UNDERLYING COAL BEDS. BITUMINOUS COAL IS ALSO FOUND IN THE ALLEGHENY AND POTTSVILLE GROUPS.

RECONNAISSANCE

A STANTEC AND ODOT REPRESENTATIVE VISITED THE SITE ON FEBRUARY 7, 2023. THE LANDSLIDE MEASURED ABOUT 70 FEET LONG ALONG THE WESTBOUND SHOULDER. SCARPING WAS OBSERVED BELOW THE GUARDRAIL OF US 35. THE GUARDRAIL WAS ALSO OBSERVED TO BE DEFLECTING AWAY FROM THE ROADWAY DUE TO SLOPE MOVEMENT. ORANGE TRAFFIC BARRELS HAD BEEN PLACED IN THE EMERGENCY LANE TO PREVENT TRAFFIC FROM STOPPING IN THE AREA OF THE LANDSLIDE. SLOUGHING WAS ALSO OBSERVED DOWN SLOPE OF THE ROADWAY. IT APPEARED THAT THE ROADWAY HAD BEEN CONSTRUCTED USING CUT-AND-FILL METHODS ALONG A HILLSIDE, CUTTING FROM HIGHER ON THE HILLSIDE AND FILLING LOWER ON THE HILLSIDE TO CREATE THE ROAD. THE LAND SURROUNDING THE PROJECT SITE CAN BE DESCRIBED AS RURAL AND RESIDENTIAL.

SUBSURFACE EXPLORATION

ONE BORING WAS ADVANCED ON APRIL 10, 2023 TO OBTAIN GEOTECHNICAL DATA FOR THE LANDSLIDE AND PROPOSED REMEDIATION. THIS BORING WAS DRILLED WITH A TRACK-MOUNTED DRILL RIG USING 3.25-INCH I.D. HOLLOW-STEM AUGERS. DISTURBED SOIL SAMPLES WERE OBTAINED IN ACCORDANCE WITH THE STANDARD PENETRATION TEST (AASHTO T206) AT CONTINUOUS INTERVALS. SHELBY TUBES WERE USED TO OBTAIN UNDISTURBED SAMPLES IN COHESIVE SOIL AT DEPTHS OF 5.5 TO 7.5 FEET AND 13.5 TO 15.5 FEET ACCORDING TO ASTM D 1587. THE AUTOMATIC SAMPLING HAMMER WAS CALIBRATED ON MARCH 14, 2022 AND HAS A DRILL ROD ENERGY RATIO (ER) OF 90 PERCENT.

EXPLORATION FINDINGS

THE SURFACE MATERIAL ENCOUNTERED CONSISTED OF 10 INCHES OF ASPHALT PAVEMENT. GRANULAR SOIL DESCRIBED AS LIGHT BROWN TO GRAY COARSE AND FINE SAND (A-3A) WAS ENCOUNTERED BELOW THE ASPHALT TO A DEPTH OF 7.5 FEET. THE SAND WAS DESCRIBED AS MEDIUM DENSE TO DENSE AND DAMP TO MOIST. FINE-GRAINED SOIL DESCRIBED AS GRAY SANDY SILT (A-4A) WAS ENCOUNTERED FROM 7.5 TO 20.0 FEET IN DEPTH. THE SOIL WAS DESCRIBED AS STIFF TO VERY STIFF AND DAMP TO MOIST. DECOMPOSED TO SEVERELY WEATHERED DARK GRAY SHALE WAS THEN ENCOUNTERED FROM A DEPTH OF 20.0 TO 25.6 FEET. THIS BEDROCK WAS SPLIT SPOON SAMPLED DUE TO THE SOIL-LIKE CONSISTENCY OF THE MATERIAL.

COMPETENT SHALE BEDROCK WAS ENCOUNTERED AT A DEPTH OF 25.6 TO 28.9 FEET THEN AGAIN AT A DEPTH OF 32.7 TO 40.8 FEET. THE SHALE WAS DESCRIBED AS DARK GRAY, SEVERELY TO MODERATELY WEATHERED, HIGHLY TO MODERATELY FRACTURED, AND ARGILLACEOUS. SILTSTONE WAS ENCOUNTERED IN THE BORING AT A DEPTH OF 28.9 TO 32.7 FEET. THE SILTSTONE WAS DESCRIBED AS GRAY, SEVERELY TO MODERATELY WEATHERED, MODERATELY FRACTURED, AND ARGILLACEOUS.

GROUNDWATER WAS ENCOUNTERED DURING DRILLING AT A DEPTH OF 24.0 FEET

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JANUARY 2023.

AVAILABLE INFORMATION

THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE SOIL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.

LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH.	CLASSIFIED VISUAL
COARSE AND FINE SAND	A-3a	2	2
SANDY SILT	A-4a	3	5
	TOTAL	5	7
SHALE	VISUAL		
SILTSTONE	VISUAL		
PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		

BORING LOCATION - PLAN VIEW.

HISTORIC BORING LOCATION - PLAN VIEW.

DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.

WC INDICATES WATER CONTENT IN PERCENT.

N_{60} INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

X/Y/Z NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X= NUMBER OF BLOWS FOR FIRST 6 INCHES.
Y= NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z= NUMBER OF BLOWS FOR THIRD 6 INCHES.

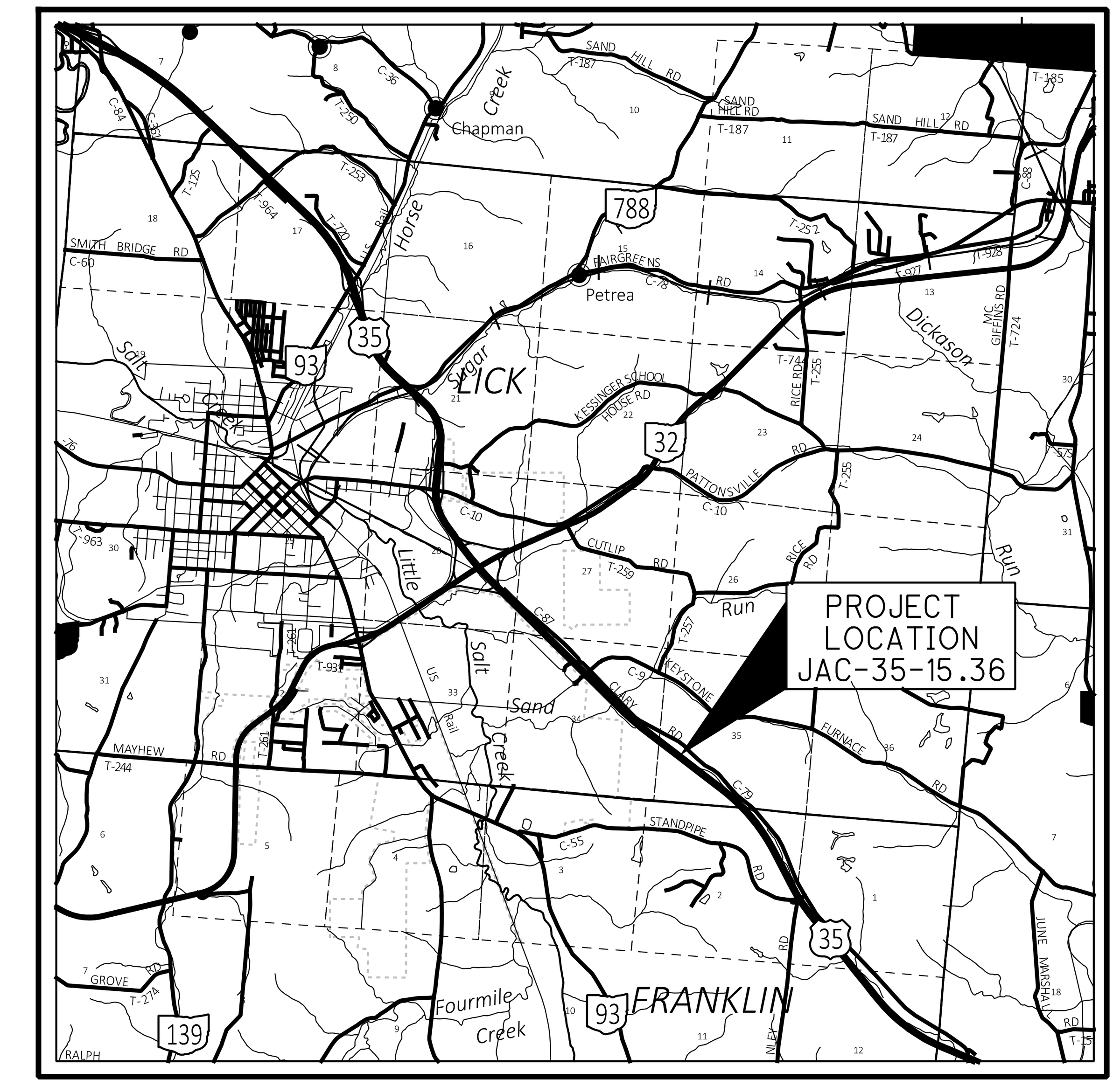
W INDICATES FREE WATER ELEVATION.

TR INDICATES TOP OF ROCK.

SS INDICATES A SPLIT SPOON SAMPLE.

NP INDICATES A NON-PLASTIC SAMPLE.

UC UNCONFINED COMPRESSIVE STRENGTH (SOIL) SHOWN IN (TSF).



LOCATION MAP

SCALE IN MILES

0 1 2 3 4

N

PARTICLE SIZE DEFINITIONS

BOULDERS	12"	COBBLES	3"	GRAVEL	2.0 mm (No. 10 SIEVE)	COARSE SAND	0.42 mm (No. 40 SIEVE)	FINE SAND	0.074 mm (No. 200 SIEVE)	SILT	0.005 mm	CLAY

RECON. - JG & EK 02/07/2023
DRILLING - TS & JS 04/10/2023
DRAWN - MJ 01/2024
REVIEWED - EMK 01/12/2024

HISTORIC BORING LEGEND

DRIVE SAMPLE SOIL TEST DATA

NOTE: NP SHOWN IN LIQUID LIMIT AND PLASTICITY INDEX COLUMNS INDICATES THAT THE MATERIAL IS NON-PLASTIC

STATION & OFFSET	DEPTH FROM TO	% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	% W.C.	SHTL CLASS
358+00 50' LT	2.5- 4.0	13	3	61	15	8	NP	NP	10	A-3A
	5.0- 6.5	12	4	56	19	9	NP	NP	8	A-3A
	7.5- 9.0	3	6	30	28	33	24	6	23	A-4A
	10.0-11.5	10	4	46	22	18	NP	NP	12	A-4A
	12.5-14.0	9	3	40	28	20	20	4	19	A-4A
	15.0-16.5	0	1	3	38	58	48	20	24	A-7-6
	17.5-19.0	0	1	2	47	50	40	15	18	A-6A
	20.0-21.5	(25	7	1	36	31	39	15	12)	
				GRAY SOFT CLAY SHALE						VISUAL
358+60 105'LT	2.5- 4.0	5	4	56	21	14	NP	NP	16	A-3A
	5.0- 6.5	20	4	40	23	13	NP	NP	17	A-4A
	7.5- 9.0	7	6	38	27	22	23	6	20	A-4A
	10.0-11.5	4	2	27	33	34	29	9	26	A-4A
	12.5-14.0	(10	1	8	57	24	27	9	12)	
				GRAY SOFT CLAY SHALE						VISUAL
	15.0-15.3	(68	10	7	11	4	--	--	5)	
				GRAY WEATHERED SHALE						VISUAL
359+00 105'LT	2.5- 4.0	7	4	54	22	13	NP	NP	15	A-3A
	5.0- 6.5	8	4	37	29	22	NP	NP	22	A-4A
	7.5- 9.0	11	3	37	25	24	21	5	29	A-4A
	10.0-11.5	3	0	9	55	33	28	10	10	A-4B
	12.5-13.5	(22	8	8	43	19	27	10	7)	
			BROWN AND GRAY SOFT CLAY SHALE							VISUAL
	15.0-15.3	(31	30	15	18	6	--	--	11)	
			GRAY WEATHERED CLAY SHALE							VISUAL
359+50 50' LT	2.5- 4.0	23	3	49	17	8	NP	NP	6	A-3A
	5.0- 5.4	(53	2	29	10	6	--	--	4)	
			GRAY SANDSTONE FRAGMENTS							VISUAL
	7.5- 9.0	2	9	37	29	23	24	6	14	A-4A
	10.0-11.5	4	5	35	33	23	24	4	18	A-4A
	12.5-14.0	5	9	24	44	18	NP	NP	6	A-4A
	15.0-15.5	(26	13	12	38	11	NP	NP	9)	
			BROWN AND GRAY SOFT CLAY SHALE							VISUAL
	17.5-18.0	(21	16	12	41	10	NP	NP	7)	
			BROWN AND GRAY SOFT CLAY SHALE							VISUAL
	20.0-20.5	(36	14	14	25	11	32	8	6)	
				GRAY WEATHERED SHALE						VISUAL

LEGEND FOR PROJECT

DESCRIPTION	OHIO CLASS
COARSE AND FINE SAND	A-3A
SANDY SILT	A-4A
SILT	A-4B
SILT AND CLAY	A-6A
CLAY	A-7-6
BOULDERY ZONE	---
WEATHERED SHALE OR CLAYSHALE	---
CLAYSHALE OR SILTSHALE	---
VARIOUS OTHER MATERIALS	---

DRIVE SAMPLE-CORE BORING-PLAN VIEW.

DRIVE SAMPLE-CORE BORING PLOTTED TO VERTICAL SCALE ONLY.

WATER CONTENT NEARLY EQUAL TO OR GREATER THAN LIQUID LIMIT.

INDICATES A NON-PLASTIC MATERIAL WITH A HIGH WATER CONTENT.

NUMBER OF BLOWS FOR "STANDARD PENETRATION" TEST.
X=NUMBER OF BLOWS FOR FIRST 6 INCHES
Y=NUMBER OF BLOWS FOR SECOND 6 INCHES
Z=NUMBER OF BLOWS FOR THIRD 6 INCHES

NOTE: FIGURES BESIDE BORINGS INDICATE WATER CONTENT IN PERCENT. e. g. 15

DRAFT

GEOTECHNICAL PROFILE - LANDSLIDE
JAC-35-15.36

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER MSJ
REVIEWER EMK 01-12-24
PROJECT ID 116242
SUBSET 0 TOTAL 0
SHEET P.18 TOTAL 24

JAC-35-15.36

MODEL: 110174_YC001 PAPERSIZE: 34x22 (in.) DATE: 1/11/2024 TIME: 12:44:58 PM USER: MJennings
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JAC-35-15.36

MODEL: PCL_Wall-3 - Plan and Profile [Sheet] PAPERSIZE: 34x22 (in.) DATE: 1/11/2024 TIME: 1:27:33 PM USER: MJennings
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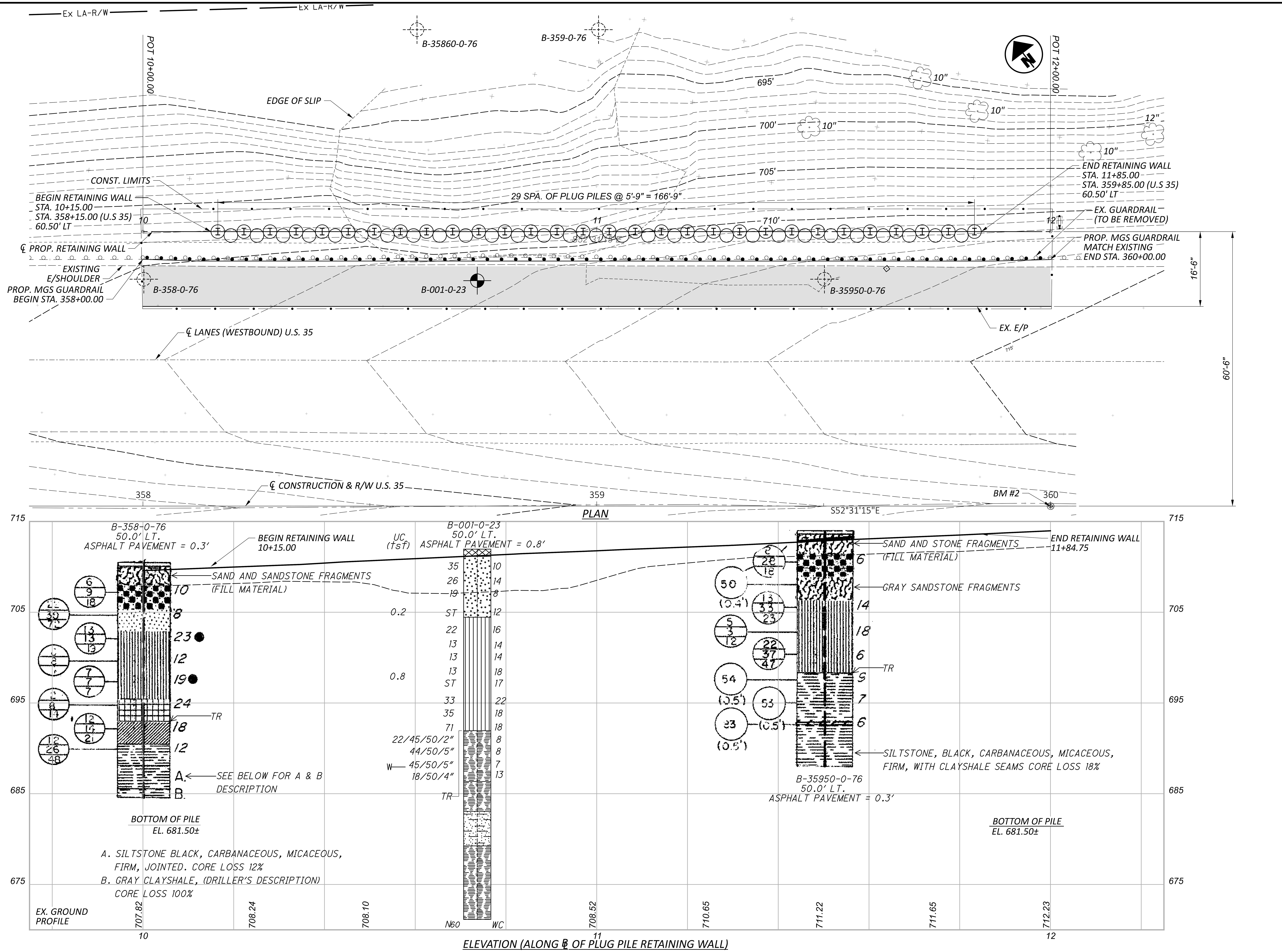


HORIZONTAL SCALE IN FEET

0 5 10 20

GEOTECHNICAL PROFILE - LANDSLIDE RETAINING WALL ALONG U.S. 35

DESIGN AGENCY

Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

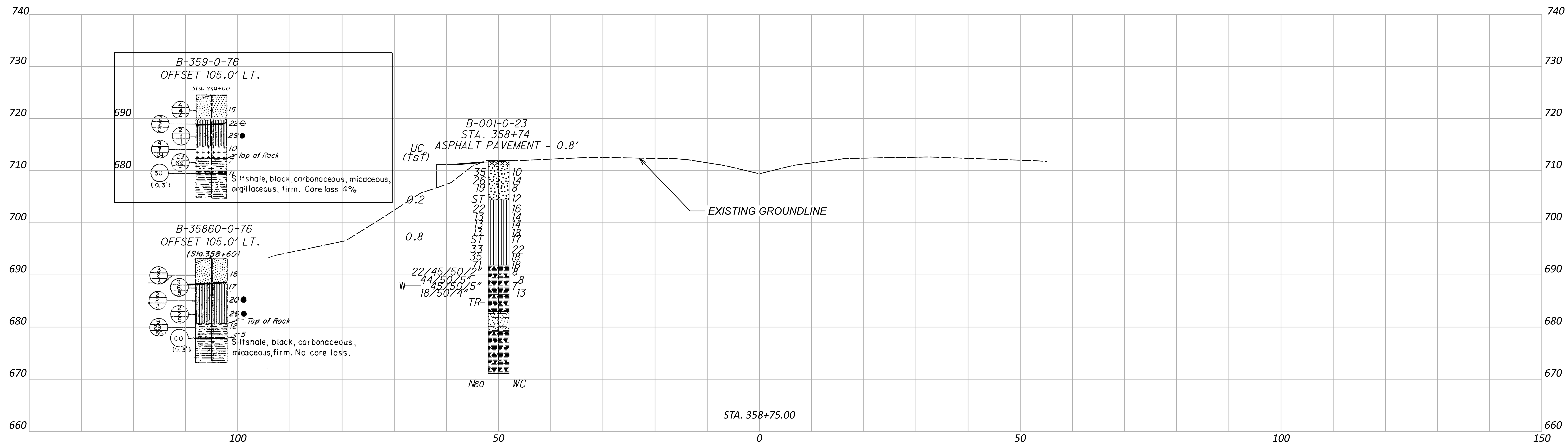
DESIGNER
MSJ

REVIEWER
EMK 01-12-24

PROJECT ID
116242

SHEET P.19 TOTAL 24

GEOTECHNICAL PROFILE - LANDSLIDE
CROSS SECTION STA. 358+75 US 35



JAC-35-15.36

MODEL: ckxu39 - 358+75.00 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 1/11/2024 TIME: 12:43:31 PM USER: Mlennings
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DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER	MSJ
REVIEWER	EMK 01-12-24
PROJECT ID	116242
SUBSET / TOTAL	0 / 0
SHEET / TOTAL	P.20 / 24

MODEL: Sheet PAPERSIZE: 34x22 (in.) DATE: 1/10/2024 TIME: 4:14:36 PM USER: MJennings
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PROJECT: JAC-35-15.36
TYPE: GEOHAZARD EXPLORATION
PID: 116242 SFN: N/A
START: 4/10/23 END: 4/10/23

DRILLING FIRM / OPERATOR: CENTRAL STAR / TS
SAMPLING FIRM / LOGGER: STANTEC / JS
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT / ST / NQ2

DRILL RIG: DIEDRICH D-50
HAMMER: DIEDRICH AUTOMATIC
CALIBRATION DATE: 3/14/22
ENERGY RATIO (%): 86.5

STATION / OFFSET: 358+74, 50' LT.
ALIGNMENT: US 35
ELEVATION: 711.9 (MSL) EOB: 40.8 ft.
LAT / LONG: 39.027416, -82.588057

EXPLORATION ID B-001-0-23
PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 711.9	DEPTHS	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
BLACK, **ASPHALT**	711.1																	
MEDIUM DENSE TO DENSE, LIGHT BROWN TO GRAY, **COARSE AND FINE SAND**, LITTLE GRAVEL, LITTLE SILT, LITTLE CLAY, DAMP TO MOIST		1–2	11 12 12	35	67	SS-1	0.75	-	-	-	-	-	-	-	-	10	A-3a (V)	
		3	10 8 10	26	94	SS-2	2.00	10	5	52	16	17	NP	NP	NP	14	A-3a (0)	
		4–5	10 6 7	19	78	SS-3	2.00	-	-	-	-	-	-	-	-	8	A-3a (V)	
UC FROM 6.5 FT. TO 7.0 FT. = 0.2 TSF	704.4	6–7			79	ST-1	-	3	7	62	22	6	NP	NP	NP	12	A-3a (0)	
STIFF TO VERY STIFF, GRAY, **SANDY SILT**, TRACE TO LITTLE GRAVEL, SOME CLAY, DAMP TO MOIST		8	4 7 8	22	72	SS-4	3.00	-	-	-	-	-	-	-	-	16	A-4a (V)	
		9–10	5 4 5	13	83	SS-5	2.50	13	7	30	23	27	27	19	8	14	A-4a (3)	
		11	5 5 4	13	78	SS-6	2.00	-	-	-	-	-	-	-	-	14	A-4a (V)	
		12–13	3 4 5	13	100	SS-7	0.50	2	7	24	33	34	24	18	6	18	A-4a (6)	
UC FROM 13.5 FT. TO 14.0 FT. = 0.8 TSF		14–15			58	ST-2	-	2	6	40	36	16	24	16	8	17	A-4a (3)	
		16	4 7 16	33	78	SS-8	-	-	-	-	-	-	-	-	-	22	A-4a (V)	
		17–18	15 12 12	35	56	SS-9	-	-	-	-	-	-	-	-	-	18	A-4a (V)	
	691.9	19 / TR 20	10 15 34	71	78	SS-10	-	-	-	-	-	-	-	-	-	18	A-4a (V)	
SHALE, DARK GRAY, DECOMPOSED TO SEVERELY WEATHERED, VERY WEAK, VERY FINE GRAINED, THINLY LAMINATED, ARGILLACEOUS.		20–21	22 45 50/2"	-	100	SS-11	-	-	-	-	-	-	-	-	-	8	Rock (V)	
		22	44 50/5"	-	100	SS-12	-	-	-	-	-	-	-	-	-	8	Rock (V)	
		23 / W 687.9	45 50/5"	-	100	SS-13	-	-	-	-	-	-	-	-	-	7	Rock (V)	
	686.3	25	18 50/4"	-	100	SS-14	-	-	-	-	-	-	-	-	-	13	Rock (V)	

BORING CONTINUES

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200
DESIGNER MSJ
REVIEWER EMK 01-12-24
PROJECT ID 116242
SUBSET 0 TOTAL 0
SHEET P.21 TOTAL 24

GEOTECHNICAL PROFILE - LANDSLIDE
BORING LOG B-001-0-23

MODEL: Sheet PAPERSIZE: 34x22 (in.) DATE: 1/11/2024 TIME: 7:55:33 AM USER: MJennings
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LOG OF BORING (CONTINUED)

PROJECT: JAC-35-15.36 TYPE: GEOHAZARD EXPLORATION PID: 116242 SFN: N/A START: 4/10/23 END: 4/10/23	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS SAMPLING FIRM / LOGGER: STANTEC / JS DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT / ST / NQ2	DRILL RIG: DIEDRICH D-50 HAMMER: DIEDRICH AUTOMATIC CALIBRATION DATE: 3/14/22 ENERGY RATIO (%): 86.5	STATION / OFFSET: 358+74, 50' LT. ALIGNMENT: US 35 ELEVATION: 711.9 (MSL) EOB: 40.8 ft. LAT / LONG: 39.027416, -82.588057

EXPLORATION ID: B-001-0-23 — PAGE 2 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 686.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
SHALE, DARK GRAY, MODERATELY TO SEVERELY WEATHERED, WEAK, VERY FINE GRAINED, THINLY LAMINATED, ARGILLACEOUS, HIGHLY TO MODERATELY FRACTURED; RQD 41%, REC 100%.	683.0	26–29	40		100	NQ2-1											CORE	
SILTSTONE, GRAY, MODERATELY TO SEVERELY WEATHERED, MODERATELY STRONG TO STRONG, FINE GRAINED, THIN BEDDED, ARGILLACEOUS, MODERATELY FRACTURED; RQD 32%, REC 100%.	679.2	29–32	26		100	NQ2-2											CORE	
SHALE, DARK GRAY, MODERATELY TO SEVERELY WEATHERED, WEAK, VERY FINE GRAINED, THINLY LAMINATED, ARGILLACEOUS, HIGHLY TO MODERATELY FRACTURED; RQD 23%, REC 100%.		33–39																
POINT LOAD INDEX = 64; UCR = 766 PSI	671.1	40, EOB	33		100	NQ2-3											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; POURED BENTONITE GROUT

DESIGN AGENCY: Stantec, 10200 Alliance Road, Suite 300, Cincinnati, OH 45242, (513) 842-8200

DESIGNER: MSJ

REVIEWER: EMK 01-12-24

PROJECT ID: 116242

SUBSET: 0 TOTAL: 0

SHEET: P.22 TOTAL: 24

GEOTECHNICAL PROFILE - LANDSLIDE
BORING LOG B-001-0-23 (CONTINUED)

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	26.5'	29.3'	44.5"/44.5"	100%	18"/44.5"	40%
NQ2-2	29.3'	39.3'	120"/120"	100%	31"/120"	26%

JAC-35-15.36, PID 112972

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-2	29.3'	39.3'	120"/120"	100%	31"/120"	26%
NQ2-3	39.3'	40.8'	18"/18"	100%	6"/18"	33%

JAC-35-15.36, PID 112972

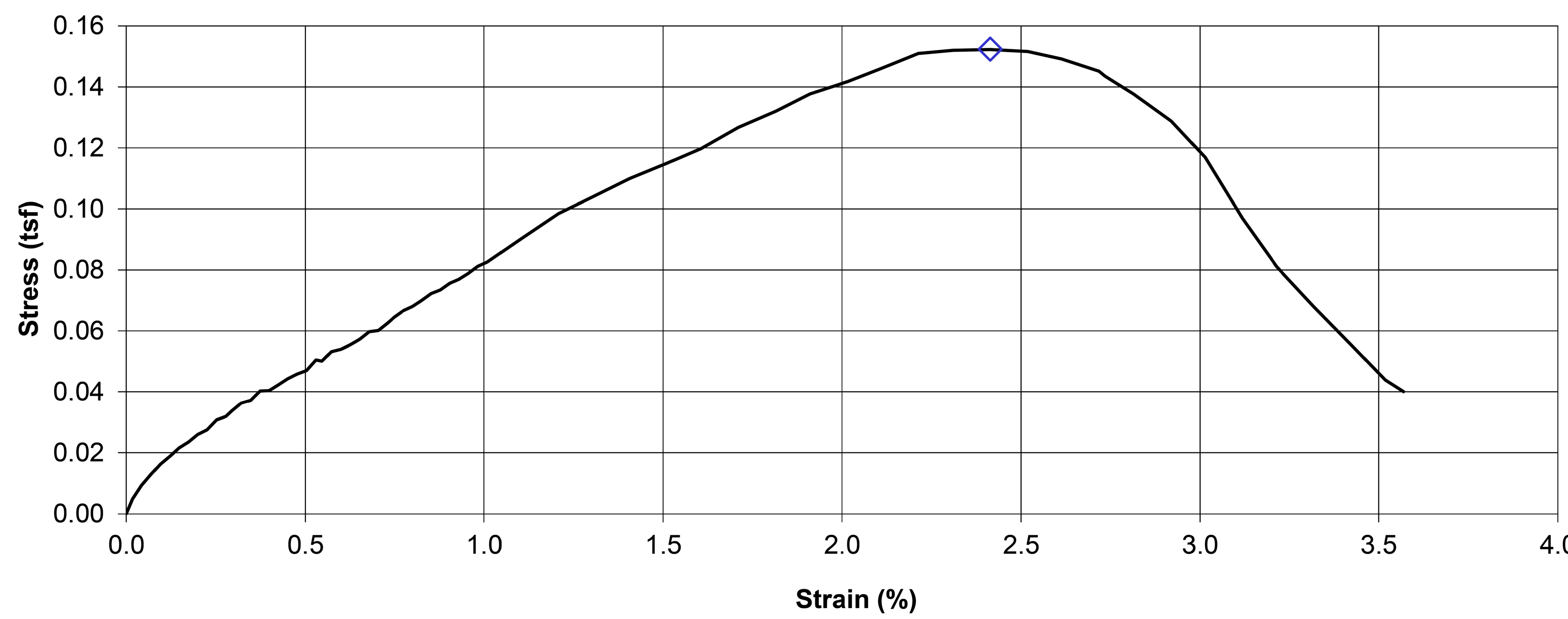
GEOTECHNICAL PROFILE - LANDSLIDE
ROCK CORE PHOTOS BORING LOG B-001-0-23

Unconfined Compressive Strength of Cohesive Soil
ASTM D 2166

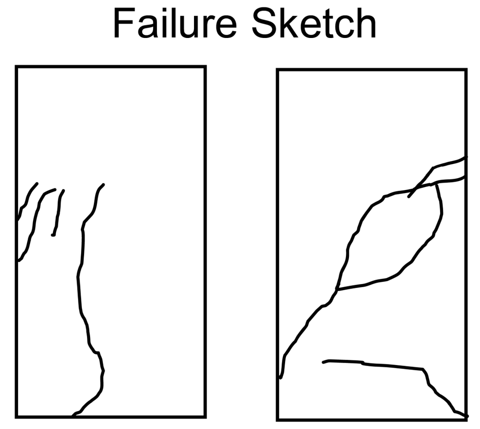
Project Name: JAC-35-15.36 Landslide — Project Number: 175578395
Source: B-001-0-23, 5.5'-7.5' — Lab ID: 1
Visual Description: Silty Sand (SM), brown, moist, soft
Recovered: 1.6'
Test Interval: 6.5' - 7.0'
Specimen Type: Undisturbed — LL: NP — PL: NP — PI: NP
Date Extruded: 04/18/2023
Date Tested: 04/19/2023

Initial Wet Density (pcf)	125.2		
Initial Moisture Content (%)	11.8	Initial MC Taken	Before Test, From Trimmings
Initial Dry Density (pcf)	111.9		
At Test Moisture Content (%)	N/A	At Test MC Taken	N/A
At Test Dry Density (pcf)	N/A		
Specific Gravity	N/A		
Degree of Saturation (%)	N/A	Unconfined Compressive Strength (tsf)	0.15
Average Height (in)	5.894	Undrained Shear Strength (tsf)	0.08
Average Diameter (in)	2.837	Strain at Maximum Stress (%)	2.4
Height to Diameter Ratio	2.1	Strain Rate to Failure (% / min.)	1.00

Stress vs. Strain



Failure Sketch



Pocket Penetrometer Reading (tsf): N/A
Torvane Reading (kg/cm^2): N/A

Comments
Classification data from ST-1:
Coarse and Fine Sand (A-3a)
%GR = 3; %CS = 7; %FS = 62; %SI = 22; %CL = 6

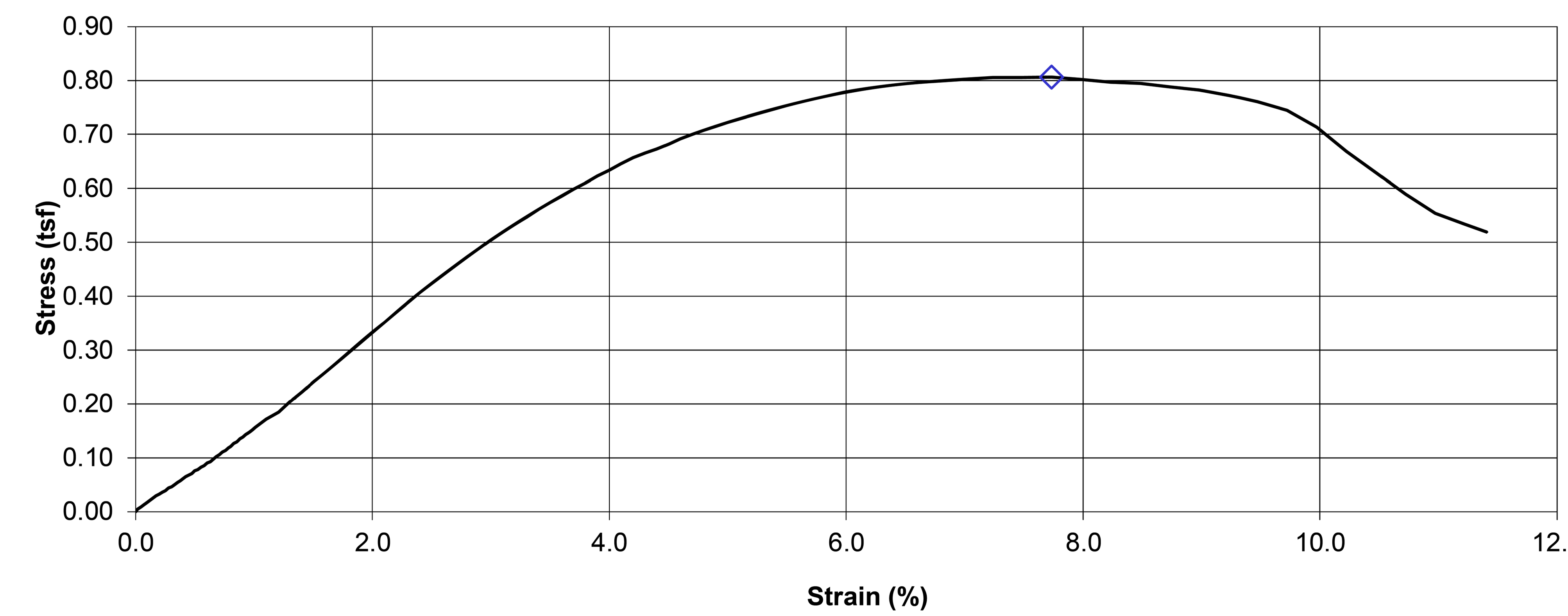
Reviewed By: RHB

Unconfined Compressive Strength of Cohesive Soil
ASTM D 2166

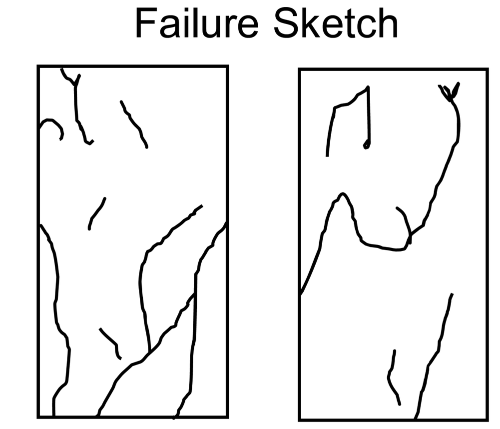
Project Name: JAC-35-15.36 Landslide — Project Number: 175578395
Source: B-001-0-23, 13.5'-15.5' — Lab ID: 2
Visual Description: Sandy Lean Clay (CL), gray brown, moist, firm
Recovered: 1.2'
Test Interval: 13.5' - 14.0'
Specimen Type: Undisturbed — LL: 24 — PL: 16 — PI: 8
Date Extruded: 04/18/2023
Date Tested: 04/19/2023

Initial Wet Density (pcf)	132.9		
Initial Moisture Content (%)	16.6	Initial MC Taken	Before Test, From Trimmings
Initial Dry Density (pcf)	114.0		
At Test Moisture Content (%)	N/A	At Test MC Taken	N/A
At Test Dry Density (pcf)	N/A		
Specific Gravity	N/A		
Degree of Saturation (%)	N/A	Unconfined Compressive Strength (tsf)	0.81
Average Height (in)	5.939	Undrained Shear Strength (tsf)	0.40
Average Diameter (in)	2.879	Strain at Maximum Stress (%)	7.7
Height to Diameter Ratio	2.1	Strain Rate to Failure (% / min.)	0.99

Stress vs. Strain



Failure Sketch



Pocket Penetrometer Reading (tsf): N/A
Torvane Reading (kg/cm^2): N/A

Comments
Classification data from ST-2:
Sandy silt (A-4a)
%GR = 2; %CS = 6; %FS = 40; %SI = 36; %CL = 16

Reviewed By: RHB

GEOTECHNICAL PROFILE - LANDSLIDE
LAB DATA SHEET

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200
DESIGNER: MSJ
REVIEWER: EMK 01-12-24
PROJECT ID: 116242
SUBSET: 0 TOTAL: 0
SHEET: P.24 TOTAL: 24

JAC-35-15.36
MODEL: Sheet_SurvFt PAPERSIZE: 34x22 (in.) DATE: 1/10/2024 TIME: 4:30:59 PM USER: MJennings
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APPENDIX B
EARTH PRESSURE CALCULATIONS

Point Load Index to Unconfined Compressive Strength of Rock

	Axial (psi)	Diametric (psi)
Is(50) values	90.2	5.5
	53.2	7.2
	38.7	3.0
	116.5	2.9
	20.5	9.2
		11.1
		42.0
		2.7
average (all)	63.82	10.45
UCS conversion (12 for incompetent rock, 24 for competent rock)	765.84	125.4

Procedure outlined in section 406.2 of ODOT Geotechnical Design Manual

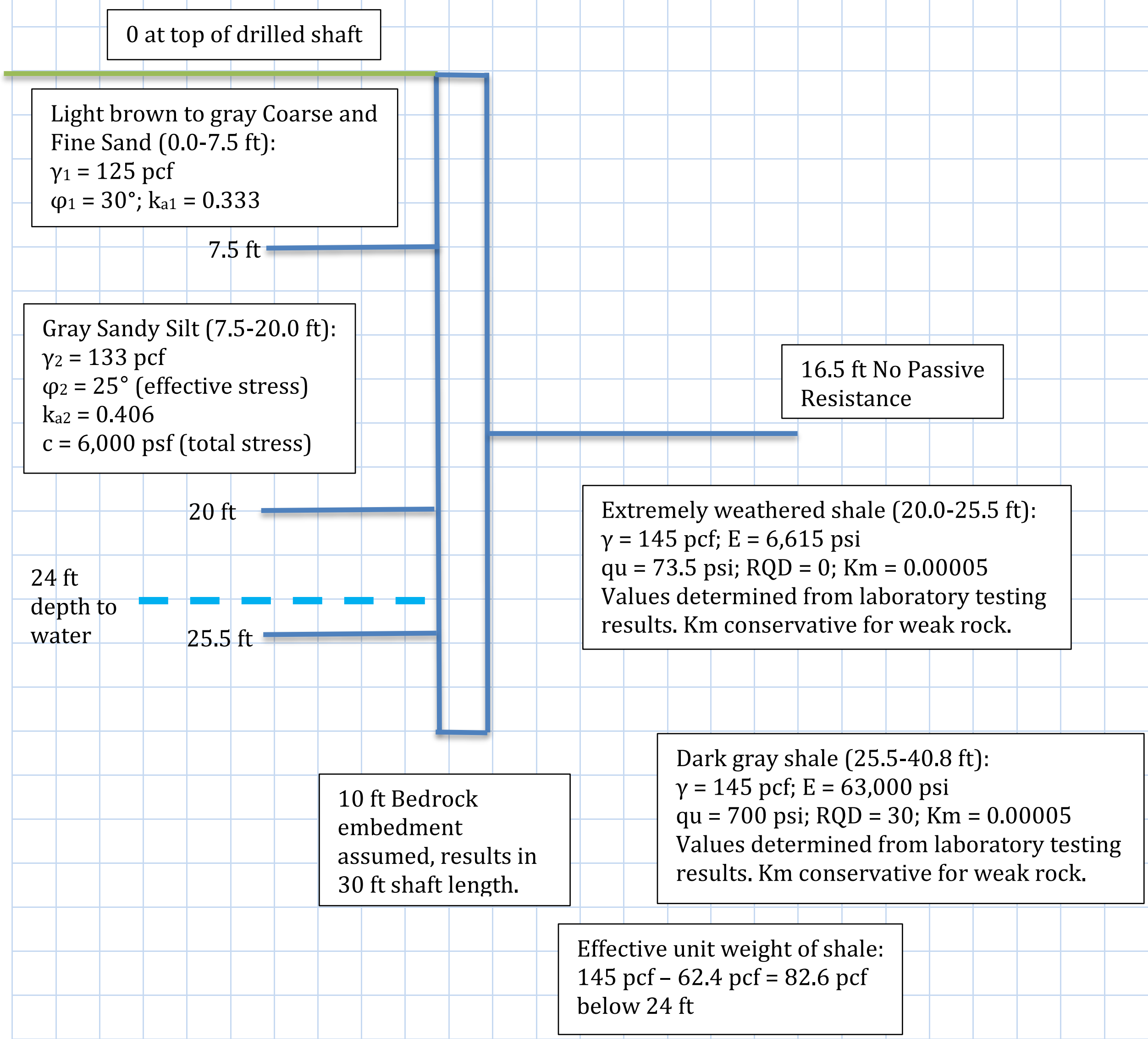
Modified Standard Penetration Test to Unconfined Compressive Strength of Weak Rock

Count	Boring ID	Sample ID	Blow Count	Penetration Depth (in)	N_{rate} (bpf) = (Blows/Penetration)*12	$(N_{rate})_{90}$ (bpf) = (2/3)*N_{rate}	Q_u (ksf) = 0.092*$(N_{rate})_{90}$	Q_u (psi) = (ksf*1000)/144
1	B-001-0-23	SS-11	50	2	300	200.00	18.4	127.8
2	B-001-0-23	SS-12	50	5	120	80.00	7.4	51.1
3	B-001-0-23	SS-13	50	5	120	80.00	7.4	51.1
4	B-001-0-23	SS-14	50	4	150	100.00	9.2	63.9
Average							10.6	73.5

Based from FHWA-ICT-17-018 “Modified Standard Penetration Test–based Drilled Shaft Design Method for Weak Rocks” (Stark et.al., 2017)
As recommended by Amal Goza during LAW-7 geotech review

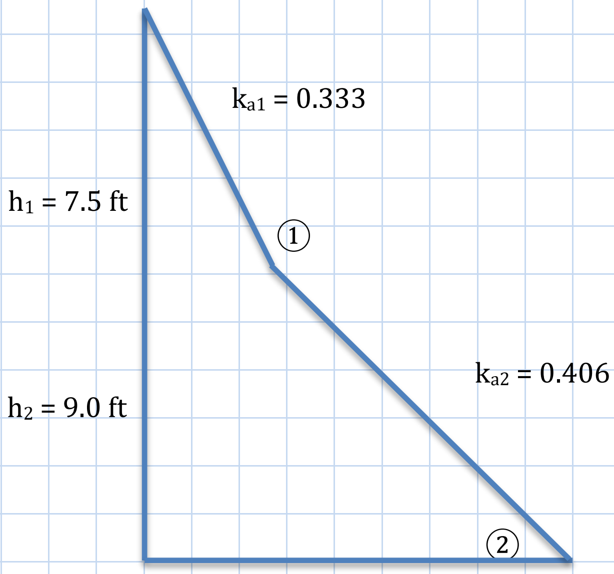
Assumptions: Top of wall is approximately elevation 712.
Centerline of wall is approximately 75 ft left from roadway centerline.
Shaft diameter = 3 ft. Shaft spacing = 5.75 ft.
No passive resistance above 16.5 ft.
Live Load (traffic) surcharge is 250 psf.

Drawing not to scale.

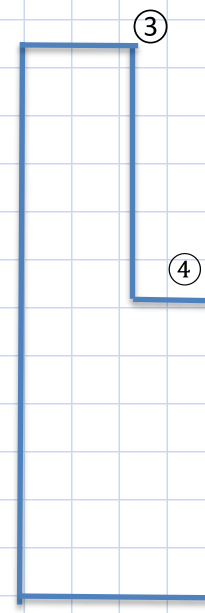


Analysis by: James Samples 5/10/2023 Checked by: Eric Kistner 5/12/2023

Soil Pressures



Surcharge
$\sigma_v = 250$ psf



① $\sigma_1 = k_{a1} \cdot \gamma_1 \cdot h_1$
$\sigma_{h1} = 0.333 * 125 * 7.5$
$\sigma_{h1} = 312.5$ psf

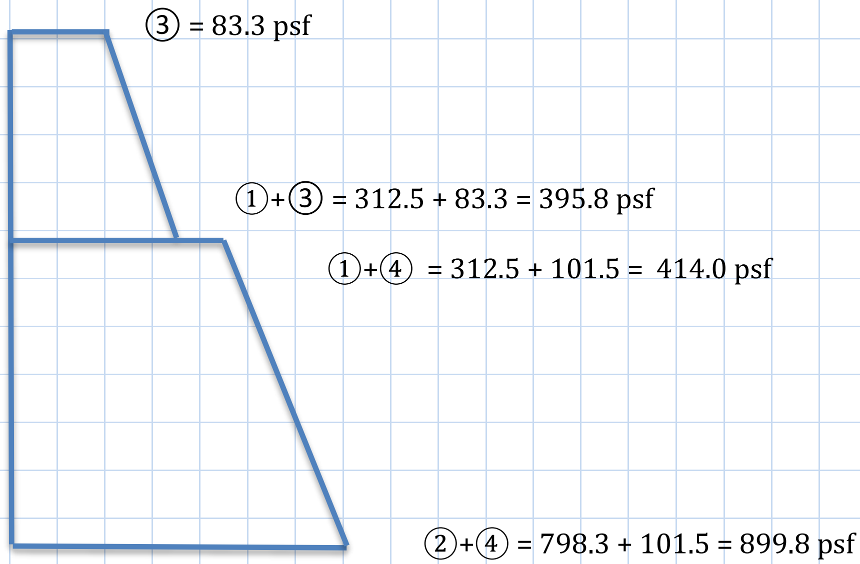
② $\sigma_2 = \sigma_{h1} + (k_{a2} \cdot \gamma_2 \cdot h_2)$
$\sigma_2 = 312.5 + (0.406 * 133 * 9)$
$\sigma_2 = 798.3$ psf

③ $\sigma_{h3} = k_{a1} \cdot \sigma_v$
$\sigma_{h3} = 0.333(250 \text{ psf})$
$\sigma_{h3} = 83.3$ psf

④ $\sigma_{h4} = k_{a2} \cdot \sigma_v$
$\sigma_{h4} = 0.406(250 \text{ psf})$
$\sigma_{h4} = 101.5$ psf

Analysis by: James Samples 5/10/2023 Checked by: Eric Kistner 5/12/2023

Superimpose earth and surcharge pressures for service state:



Assume a pile center-to-center spacing of 5.75 ft in order to figure the lateral load per pile for an LPile analysis.

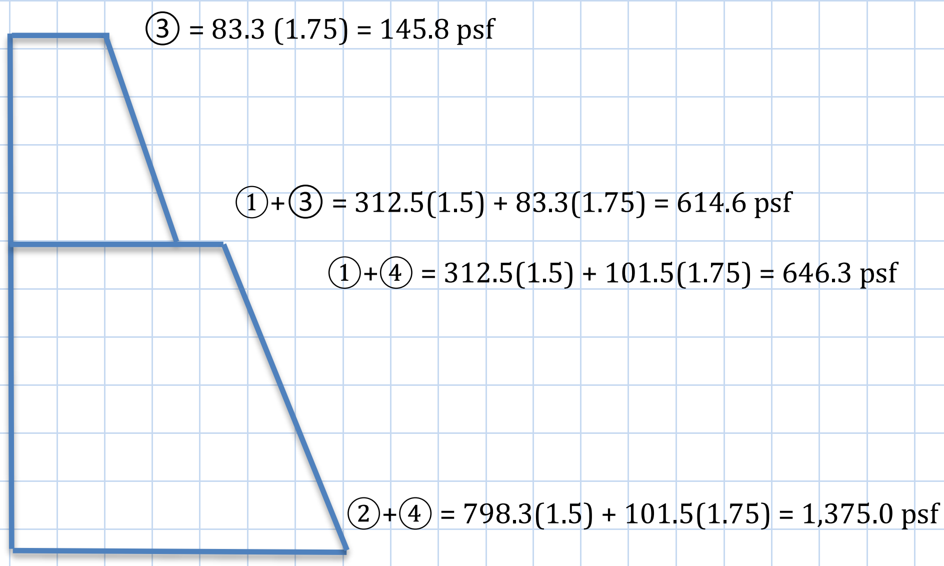
At the top of the pile:
5.75 x 83.3 = 479.2 lbs/ft or 39.9 lbs/in.

At the top of the soil layer interface:
5.75 x 395.8 = 2,276.0 lbs/ft or 189.7 lbs/in.

At the bottom of the soil layer interface:
5.75 x 414.0 = 2,380.3 lbs/ft or 198.4 lbs/in.

At the bottom of the pile:
5.75 x 899.8 = 5,173.7 lbs/ft or 431.1 lbs/in.

Superimpose earth and surcharge pressures for strength state (utilizing 1.5 factor for earth pressure and 1.75 factor for surcharge pressure from 9th Edition AASHTO LRFD):



Assume a pile center-to-center spacing of 5.75 ft in order to figure the lateral load per pile for an LPile analysis.

At the top of the pile:
5.75 x 145.8= 838.5 lbs/ft or 69.9 lbs/in.

At the top of the soil layer interface:
5.75 x 614.6 = 3,533.9 lbs/ft or 294.5 lbs/in.

At the bottom of the soil layer interface:
5.75 x 646.3 = 3,716.3 lbs/ft or 309.7 lbs/in.

At the bottom of the pile:
5.75 x 1,375.0 = 7,906.4 lbs/ft or 658.9 lbs/in.

p-y Modification Factor:

$p = 0.64\ (\text{shaft spacing/shaft diameter})^{0.34}$
$= 0.64\ (5.75/3)^{0.34} = 0.8$

Following original design using 3 ft shaft diameter at 5.75 ft center-to-center spacing, it was determined that 2.5 ft shaft diameter at 4.75 ft spacing may be utilized. Loading calculations for 4.75 ft spacing follow.

Service Loads:

At the top of the pile:
4.75 x 83.3 = 395.8 lbs/ft or 33.0 lbs/in.

At the top of the soil layer interface:
4.75 x 395.8 = 1,880.2 lbs/ft or 156.7 lbs/in.

At the bottom of the soil layer interface:
4.75 x 414.0 = 1,966.3 lbs/ft or 163.9 lbs/in.

At the bottom of the pile:
4.75 x 899.8 = 4,273.9 lbs/ft or 356.2 lbs/in.

Strength Loads:

At the top of the pile:
4.75 x 145.8= 692.7 lbs/ft or 57.7 lbs/in.

At the top of the soil layer interface:
4.75 x 614.6 = 2,919.3 lbs/ft or 243.3 lbs/in.

At the bottom of the soil layer interface:
4.75 x 646.3 = 3,070.0 lbs/ft or 255.8 lbs/in.

At the bottom of the pile:
4.75 x 1,375.0 = 6,531.4 lbs/ft or 544.3 lbs/in.

p-y Modification Factor:

$p = 0.64\ (\text{shaft spacing/shaft diameter})^{0.34}$
$= 0.64\ (4.75/2.5)^{0.34} = 0.8$

From FHWA-NHI-16-072:

Table 7-5 Relationship among relative density, SPT *N*-value, and ϕ' for coarse-grained soils (after Meyerhof, 1956)

Condition	Relative Density (%)	SPT *N*-value (blows/ft)	Friction Angle, ϕ' (deg)
Very Loose	< 20	<4	<30
Loose	20-40	4-10	30-35
Compact	40-60	10-30	35-40
Dense	60-80	30-50	40-45
Very Dense	>80	>50	>45

Note: $N = 15 + (N' - 15)/2$ for $N' > 15$ in saturated very fine or silty sand, where N'= measured blow count and N = blow count corrected for dynamic pore pressure effects during the SPT.

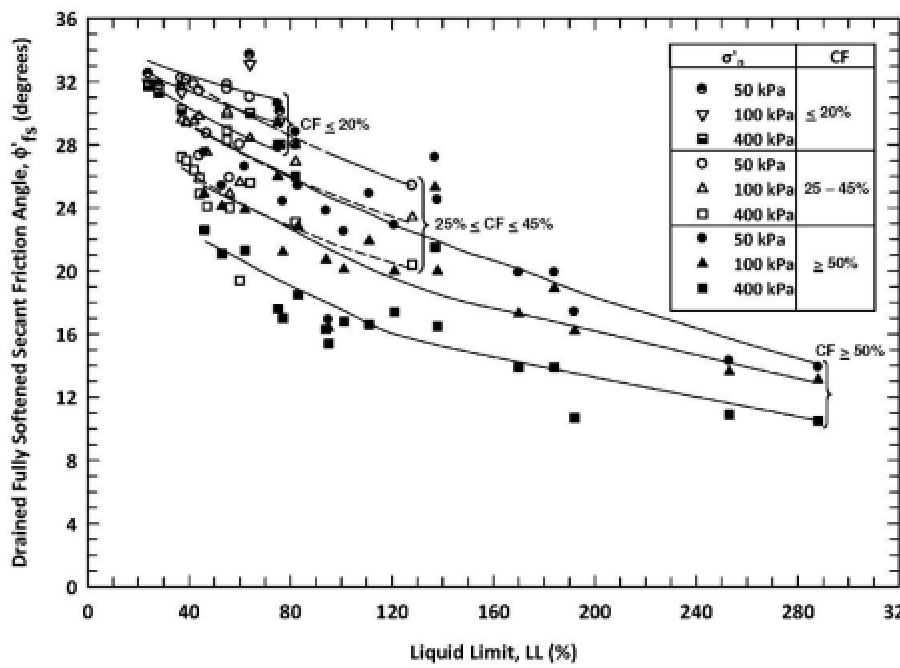


Figure 7-49 Estimated drained, fully softened friction angle from *LL* and *CF* (from Stark and Hussain, 2013)

APPENDIX C
LPILE ANALYSES

==

LPile for Windows, Version 2019-11.001

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

This copy of LPile is being used by:

Stantec Consulting Ltd.
Stantec Consulting Ltd.
Serial Number of Security Device: 253581973

This copy of LPile is licensed for exclusive use by:

STANTEC, LPILE Global, Global Li

Files Used for Analysis

Path to file locations on this computer:
\\us0268-ppfss01\shared_projects\175578395\technical_production\analysis\Lpile\

Name of the input data file:
JAC-35 design_3ft shaft diameter.lp11

Name of the output report file:
JAC-35 design_3ft shaft diameter.lp11

Name of the plot output file:
JAC-35 design_3ft shaft diameter.lp11

Name of the runtime message file:
JAC-35 design_3ft shaft diameter.lp11

Date and Time of Analysis

Date: May 18, 2023   Time: 9:36:59

Problem Title

Project Name: JAC-35-15.36

Job Number: 175578395

Client: ODOT

Engineer: J. Samples

Description: Landslide Remediation

Program Options and Settings

Computational Options:
 - Use unfactored loads in computations (conventional analysis)

Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

```
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - Analysis includes loading by multiple distributed lateral loads acting on pile
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using narrow report formats
   (Note: Some output information is omitted from the narrow report formats)



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =            2
Total length of pile                                   =       30.000 ft
```

Depth of ground surface below top of pile = 16.5000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	8.9700
2	9.000	8.9700
3	9.000	36.0000
4	30.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile
Length of section = 9.000000 ft
AISC Section Type = W

AISC Section Name = W24X68

Pile width = 8.970000 in
Shear capacity of section = 0.0000 lbs

Pile Section No. 2:

Section 2 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 21.000000 ft
Width of top of section = 36.000000 in
Width of bottom of section = 36.000000 in

```
   Top Area                                          =    20.100000 sq. in
   Bottom Area                                       =    20.100000 sq. in
   Moment of Inertia at Top                          =        1830. in^4
   Moment of Inertia at Bottom                       =        1830. in^4
   Elastic Modulus                                   =    29000000. psi
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                   =        0.000 degrees
                                                     =        0.000 radians

Pile Batter Angle                                    =        0.000 degrees
                                                     =        0.000 radians
```

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is soft clay, p-y criteria by Matlock, 1970

```
   Distance from top of pile to top of layer         =    16.500000 ft
   Distance from top of pile to bottom of layer      =    20.000000 ft
   Effective unit weight at top of layer             =   133.000000 pcf
   Effective unit weight at bottom of layer          =   133.000000 pcf
   Undrained cohesion at top of layer                =        6000. psf
   Undrained cohesion at bottom of layer             =        6000. psf
   Epsilon-50 at top of layer                        =       0.0000
   Epsilon-50 at bottom of layer                     =       0.0000
```

NOTE: Default values for Epsilon-50 will be computed for this layer.

```
Layer 2 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    20.000000 ft
   Distance from top of pile to bottom of layer       =    24.000000 ft
   Effective unit weight at top of layer              =   145.000000 pcf
   Effective unit weight at bottom of layer           =   145.000000 pcf
   Uniaxial compressive strength at top of layer      =    73.500000 psi
   Uniaxial compressive strength at bottom of layer   =    73.500000 psi
   Initial modulus of rock at top of layer            =        6615. psi
   Initial modulus of rock at bottom of layer         =        6615. psi
   RQD of rock at top of layer                        =       0.0000 %
   RQD of rock at bottom of layer                     =       0.0000 %
   k rm of rock at top of layer                       =    0.0000500
   k rm of rock at bottom of layer                    =    0.0000500


Layer 3 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    24.000000 ft
   Distance from top of pile to bottom of layer       =    25.500000 ft
   Effective unit weight at top of layer              =    82.600000 pcf
   Effective unit weight at bottom of layer           =    82.600000 pcf
   Uniaxial compressive strength at top of layer      =    73.500000 psi
   Uniaxial compressive strength at bottom of layer   =    73.500000 psi
   Initial modulus of rock at top of layer            =        6615. psi
   Initial modulus of rock at bottom of layer         =        6615. psi
   RQD of rock at top of layer                        =       0.0000 %
   RQD of rock at bottom of layer                     =       0.0000 %
   k rm of rock at top of layer                       =    0.0000500
   k rm of rock at bottom of layer                    =    0.0000500


Layer 4 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    25.500000 ft
   Distance from top of pile to bottom of layer       =    40.000000 ft
   Effective unit weight at top of layer              =    82.600000 pcf
   Effective unit weight at bottom of layer           =    82.600000 pcf
   Uniaxial compressive strength at top of layer      =   700.000000 psi
   Uniaxial compressive strength at bottom of layer   =   700.000000 psi
```

Initial modulus of rock at top of layer = 63000. psi
Initial modulus of rock at bottom of layer = 63000. psi
RQD of rock at top of layer = 30.000000 %
RQD of rock at bottom of layer = 30.000000 %
k rm of rock at top of layer = 0.0000500
k rm of rock at bottom of layer = 0.0000500

(Depth of the lowest soil layer extends 10.000 ft below the pile tip)

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 4 points

Point No.	Depth X ft	p-mult	y-mult
1	16.500	0.8000	1.0000
2	20.000	0.8000	1.0000
3	20.000	1.0000	1.0000
4	40.000	1.0000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 4 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	39.900
2	90.000	189.700
3	90.000	198.400
4	198.000	431.100

Distributed lateral load intensity for Load Case 2 defined using 4 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	69.900
2	90.000	294.500
3	90.000	309.700
4	198.000	658.900

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000
2	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000

V = shear force applied normal to pile axis
M = bending moment applied to pile head

```
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.



--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel AISC Strong Axis:
---------------------------------------------

Length of Section                                      =     9.000000 ft
Flange Width                                           =     8.970000 in
Section Depth                                          =    23.700000 in
Flange Thickness                                       =     0.585000 in
Web Thickness                                          =     0.415000 in
Yield Stress of Pipe                                   =    50.000000 ksi
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =    20.100000 sq. in.
Moment of Inertia                                      =        1830. in^4
Elastic Bending Stiffness                              =    53070000. kip-in^2
Plastic Modulus, Z                                     =   177.000000in^3
Plastic Moment Capacity = Fy Z                         =        8850.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                 =     1005.000 kips
```

Nominal Axial Tensile Capacity = -1005.000 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000081690	425.2085211868	52051526.	11.8500000000	
0.0000163380	850.4170423737	52051526.	11.8500000000	
0.0000245070	1276.	52051526.	11.8500000000	
0.0000326760	1701.	52051526.	11.8500000000	
0.0000408450	2126.	52051526.	11.8500000000	
0.0000490140	2551.	52051526.	11.8500000000	
0.0000571829	2976.	52051526.	11.8500000000	
0.0000653519	3402.	52051526.	11.8500000000	
0.0000735209	3827.	52051526.	11.8500000000	
0.0000816899	4252.	52051526.	11.8500000000	
0.0000898589	4677.	52051526.	11.8500000000	
0.0000980279	5103.	52051526.	11.8500000000	
0.0001061969	5528.	52051526.	11.8500000000	
0.0001143659	5953.	52051526.	11.8500000000	
0.0001225349	6378.	52051526.	11.8500000000	
0.0001307039	6803.	52051526.	11.8500000000	
0.0001388729	7229.	52051526.	11.8500000000	

0.0001470419	7652.	52042833.	11.8500000000	Y
0.0001552109	7838.	50500821.	11.8500000000	Y
0.0001633798	7922.	48486592.	11.8500000000	Y
0.0001715488	7993.	46594764.	11.8500000000	Y
0.0001797178	8055.	44822614.	11.8500000000	Y
0.0001878868	8109.	43161079.	11.8500000000	Y
0.0001960558	8157.	41604713.	11.8500000000	Y
0.0002042248	8199.	40146617.	11.8500000000	Y
0.0002123938	8236.	38777196.	11.8500000000	Y
0.0002205628	8269.	37490901.	11.8500000000	Y
0.0002287318	8299.	36281755.	11.8500000000	Y
0.0002369008	8325.	35143326.	11.8500000000	Y
0.0002450698	8350.	34069950.	11.8500000000	Y
0.0002532388	8371.	33056614.	11.8500000000	Y
0.0002614078	8391.	32098851.	11.8500000000	Y
0.0002695768	8409.	31192658.	11.8500000000	Y
0.0002777457	8425.	30334426.	11.8500000000	Y
0.0002859147	8440.	29520887.	11.8500000000	Y
0.0002940837	8454.	28747201.	11.8500000000	Y
0.0003022527	8467.	28011950.	11.8500000000	Y
0.0003104217	8479.	27313145.	11.8500000000	Y
0.0003185907	8489.	26646114.	11.8500000000	Y
0.0003349287	8509.	25404045.	11.8500000000	Y
0.0003512667	8525.	24269891.	11.8500000000	Y
0.0003676047	8540.	23230502.	11.8500000000	Y
0.0003839426	8552.	22274856.	11.8500000000	Y
0.0004002806	8563.	21393629.	11.8500000000	Y
0.0004166186	8574.	20578856.	11.8500000000	Y
0.0004329566	8582.	19822080.	11.8500000000	Y
0.0004492946	8590.	19118712.	11.8500000000	Y
0.0004656326	8597.	18463216.	11.8500000000	Y
0.0004819706	8603.	17850143.	11.8500000000	Y
0.0004983085	8609.	17276698.	11.8500000000	Y
0.0005146465	8614.	16737969.	11.8500000000	Y
0.0005309845	8619.	16231961.	11.8500000000	Y
0.0005473225	8623.	15755261.	11.8500000000	Y
0.0005636605	8627.	15305379.	11.8500000000	Y
0.0005799985	8631.	14880841.	11.8500000000	Y
0.0005963364	8634.	14478362.	11.8500000000	Y
0.0006126744	8637.	14097185.	11.8500000000	Y

0.0006290124	8640.	13735810.	11.8500000000	Y
0.0006453504	8642.	13391895.	11.8500000000	Y
0.0006616884	8645.	13064734.	11.8500000000	Y
0.0006780264	8647.	12753339.	11.8500000000	Y
0.0006943644	8649.	12456521.	11.8500000000	Y
0.0007107023	8651.	12172614.	11.8500000000	Y
0.0007270403	8653.	11901466.	11.8500000000	Y
0.0007433783	8655.	11642237.	11.8500000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	8655.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	16.5000	0.00	N.A.	No	0.00	210483.
2	20.0000	3.5000	No	Yes	N.A.	N.A.
3	24.0000	7.5000	No	Yes	N.A.	N.A.
4	25.5000	9.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness in-lb^2
0.000	1.62662	8.918E-06	0.000	0.000	5.205E+10

0.30000	1.59796	268.25902	157.12200	0.000	5.205E+10
0.60000	1.56931	1131.	333.11880	0.000	5.205E+10
0.90000	1.54066	2667.	530.68680	0.000	5.205E+10
1.20000	1.51201	4952.	749.82600	0.000	5.205E+10
1.50000	1.48336	8065.	990.53640	0.000	5.205E+10
1.80000	1.45472	12084.	1253.	0.000	5.205E+10
2.10000	1.42607	17086.	1537.	0.000	5.205E+10
2.40000	1.39743	23148.	1842.	0.000	5.205E+10
2.70000	1.36880	30349.	2169.	0.000	5.205E+10
3.00000	1.34017	38766.	2518.	0.000	5.205E+10
3.30000	1.31156	48476.	2888.	0.000	5.205E+10
3.60000	1.28295	59558.	3280.	0.000	5.205E+10
3.90000	1.25436	72088.	3693.	0.000	5.205E+10
4.20000	1.22579	86146.	4128.	0.000	5.205E+10
4.50000	1.19724	101807.	4584.	0.000	5.205E+10
4.80000	1.16872	119151.	5062.	0.000	5.205E+10
5.10000	1.14022	138254.	5562.	0.000	5.205E+10
5.40000	1.11176	159195.	6083.	0.000	5.205E+10
5.70000	1.08334	182050.	6625.	0.000	5.205E+10
6.00000	1.05496	206898.	7190.	0.000	5.205E+10
6.30000	1.02664	233816.	7776.	0.000	5.205E+10
6.60000	0.99837	262882.	8383.	0.000	5.205E+10
6.90000	0.97017	294174.	9012.	0.000	5.205E+10
7.20000	0.94205	327768.	9663.	0.000	5.205E+10
7.50000	0.91400	363744.	10343.	0.000	5.205E+10
7.80000	0.88604	402238.	11064.	0.000	5.205E+10
8.10000	0.85819	443403.	11820.	0.000	5.205E+10
8.40000	0.83045	487340.	12604.	0.000	5.205E+10
8.70000	0.80282	534151.	13416.	0.000	5.205E+10
9.00000	0.77533	583934.	14256.	0.000	5.205E+10
9.30000	0.74799	636792.	15124.	0.000	5.307E+10
9.60000	0.72080	692824.	16019.	0.000	5.307E+10
9.90000	0.69378	752131.	16943.	0.000	5.307E+10
10.20000	0.66694	814813.	17895.	0.000	5.307E+10
10.50000	0.64030	880972.	18874.	0.000	5.307E+10
10.80000	0.61388	950707.	19882.	0.000	5.307E+10
11.10000	0.58769	1024119.	20917.	0.000	5.307E+10
11.40000	0.56175	1101308.	21980.	0.000	5.307E+10
11.70000	0.53608	1182376.	23071.	0.000	5.307E+10
12.00000	0.51070	1267423.	24191.	0.000	5.307E+10

12.30000	0.48562	1356548.	25338.	0.000	5.307E+10
12.60000	0.46088	1449853.	26513.	0.000	5.307E+10
12.90000	0.43649	1547439.	27715.	0.000	5.307E+10
13.20000	0.41248	1649405.	28946.	0.000	5.307E+10
13.50000	0.38888	1755852.	30205.	0.000	5.307E+10
13.80000	0.36570	1866882.	31492.	0.000	5.307E+10
14.10000	0.34298	1982593.	32806.	0.000	5.307E+10
14.40000	0.32074	2103087.	34149.	0.000	5.307E+10
14.70000	0.29901	2228465.	35519.	0.000	5.307E+10
15.00000	0.27783	2358827.	36918.	0.000	5.307E+10
15.30000	0.25723	2494273.	38344.	0.000	5.307E+10
15.60000	0.23723	2634904.	39798.	0.000	5.307E+10
15.90000	0.21788	2780821.	41280.	0.000	5.307E+10
16.20000	0.19921	2932123.	42790.	0.000	5.307E+10
16.50000	0.18125	3088912.	41361.	-1432.	5.307E+10
16.80000	0.16405	3229924.	36629.	-1411.	5.307E+10
17.10000	0.14764	3352644.	31591.	-1388.	5.307E+10
17.40000	0.13204	3457379.	26642.	-1361.	5.307E+10
17.70000	0.11729	3544468.	21794.	-1332.	5.307E+10
18.00000	0.10341	3614293.	17056.	-1300.	5.307E+10
18.30000	0.09041	3667272.	12441.	-1264.	5.307E+10
18.60000	0.07830	3703865.	7959.	-1226.	5.307E+10
18.90000	0.06710	3724575.	3622.	-1184.	5.307E+10
19.20000	0.05680	3729947.	-556.34145	-1138.	5.307E+10
19.50000	0.04742	3720570.	-4565.	-1089.	5.307E+10
19.80000	0.03895	3697081.	-8389.	-1036.	5.307E+10
20.10000	0.03138	3660168.	-15239.	-2770.	5.307E+10
20.40000	0.02470	3587361.	-25663.	-3022.	5.307E+10
20.70000	0.01890	3475391.	-36790.	-3160.	5.307E+10
21.00000	0.01395	3322471.	-48306.	-3238.	5.307E+10
21.30000	0.009811	3127590.	-59980.	-3248.	5.307E+10
21.60000	0.006434	2890616.	-71546.	-3178.	5.307E+10
21.90000	0.003764	2612460.	-82669.	-3002.	5.307E+10
22.20000	0.001731	2295402.	-92148.	-2265.	5.307E+10
22.50000	0.000259	1948994.	-96875.	-361.59087	5.307E+10
22.80000	-0.000737	1597899.	-95556.	1095.	5.307E+10
23.10000	-0.001343	1260989.	-89783.	2113.	5.307E+10
23.40000	-0.001641	951459.	-81074.	2726.	5.307E+10
23.70000	-0.001707	677257.	-70793.	2986.	5.307E+10
24.00000	-0.001607	441747.	-60105.	2953.	5.307E+10

24.30000	-0.001399	244504.	-49939.	2695.	5.307E+10
24.60000	-0.001132	82183.	-40986.	2280.	5.307E+10
24.90000	-0.000844	-50595.	-33688.	1775.	5.307E+10
25.20000	-0.000569	-160368.	-28247.	1247.	5.307E+10
25.50000	-0.000333	-253977.	-12977.	7237.	5.307E+10
25.80000	-0.000160	-253800.	6524.	3597.	5.307E+10
26.10000	-4.768E-05	-207003.	15006.	1115.	5.307E+10
26.40000	1.367E-05	-145757.	16417.	-331.19913	5.307E+10
26.70000	3.944E-05	-88803.	14041.	-988.33519	5.307E+10
27.00000	4.352E-05	-44658.	10234.	-1127.	5.307E+10
27.30000	3.669E-05	-15121.	6439.	-981.05562	5.307E+10
27.60000	2.617E-05	1703.	3374.	-721.71860	5.307E+10
27.90000	1.606E-05	9172.	1253.	-456.52407	5.307E+10
28.20000	8.199E-06	10726.	-0.34609	-239.89520	5.307E+10
28.50000	2.953E-06	9170.	-592.16705	-88.89422	5.307E+10
28.80000	-5.279E-08	6462.	-749.23682	1.63323	5.307E+10
29.10000	-1.481E-06	3775.	-662.33698	46.64446	5.307E+10
29.40000	-1.987E-06	1693.	-465.72699	62.58332	5.307E+10
29.70000	-2.079E-06	422.24479	-235.18362	65.49633	5.307E+10
30.00000	-2.069E-06	0.000	0.000	65.16123	5.307E+10

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     1.62661554 inches
Computed slope at pile head      =    -0.00795861 radians
Maximum bending moment           =       3729947. inch-lbs
Maximum shear force              =        -96875. lbs
Depth of maximum bending moment  =    19.20000000 feet below pile head
Depth of maximum shear force     =    22.50000000 feet below pile head
Number of iterations             =             19
Number of zero deflection points =              3
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

JAC-35 design_3ft shaft diameter

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness in-lb^2
0.000	2.86301	-8.026E-05	2.477E-07	0.000	5.205E+10
0.30000	2.81382	467.50605	271.85401	0.000	5.205E+10
0.60000	2.76463	1957.	572.00760	0.000	5.205E+10
0.90000	2.71544	4586.	904.50360	0.000	5.205E+10
1.20000	2.66626	8470.	1269.	0.000	5.205E+10
1.50000	2.61707	13725.	1667.	0.000	5.205E+10
1.80000	2.56789	20469.	2096.	0.000	5.205E+10
2.10000	2.51871	28817.	2558.	0.000	5.205E+10
2.40000	2.46954	38886.	3052.	0.000	5.205E+10
2.70000	2.42038	50792.	3579.	0.000	5.205E+10
3.00000	2.37124	64652.	4138.	0.000	5.205E+10
3.30000	2.32211	80582.	4729.	0.000	5.205E+10
3.60000	2.27299	98699.	5352.	0.000	5.205E+10
3.90000	2.22391	119120.	6008.	0.000	5.205E+10
4.20000	2.17485	141959.	6697.	0.000	5.205E+10
4.50000	2.12583	167335.	7417.	0.000	5.205E+10
4.80000	2.07685	195363.	8170.	0.000	5.205E+10
5.10000	2.02792	226160.	8955.	0.000	5.205E+10
5.40000	1.97905	259842.	9773.	0.000	5.205E+10
5.70000	1.93024	296525.	10623.	0.000	5.205E+10
6.00000	1.88150	336327.	11505.	0.000	5.205E+10
6.30000	1.83285	379364.	12420.	0.000	5.205E+10
6.60000	1.78429	425751.	13367.	0.000	5.205E+10
6.90000	1.73584	475606.	14346.	0.000	5.205E+10
7.20000	1.68750	529045.	15358.	0.000	5.205E+10
7.50000	1.63930	586184.	16416.	0.000	5.205E+10
7.80000	1.59125	647242.	17539.	0.000	5.205E+10
8.10000	1.54335	712465.	18717.	0.000	5.205E+10
8.40000	1.49563	782004.	19937.	0.000	5.205E+10
8.70000	1.44811	856009.	21198.	0.000	5.205E+10
9.00000	1.40080	934630.	22502.	0.000	5.205E+10

9.30000	1.35372	1018020.	23847.	0.000	5.307E+10
9.60000	1.30690	1106329.	25234.	0.000	5.307E+10
9.90000	1.26034	1199708.	26664.	0.000	5.307E+10
10.20000	1.21407	1298306.	28135.	0.000	5.307E+10
10.50000	1.16813	1402277.	29648.	0.000	5.307E+10
10.80000	1.12252	1511769.	31203.	0.000	5.307E+10
11.10000	1.07728	1626935.	32799.	0.000	5.307E+10
11.40000	1.03244	1747925.	34438.	0.000	5.307E+10
11.70000	0.98803	1874889.	36119.	0.000	5.307E+10
12.00000	0.94408	2007980.	37841.	0.000	5.307E+10
12.30000	0.90061	2147346.	39606.	0.000	5.307E+10
12.60000	0.85767	2293140.	41412.	0.000	5.307E+10
12.90000	0.81529	2445513.	43260.	0.000	5.307E+10
13.20000	0.77351	2604614.	45150.	0.000	5.307E+10
13.50000	0.73237	2770596.	47082.	0.000	5.307E+10
13.80000	0.69190	2943608.	49056.	0.000	5.307E+10
14.10000	0.65215	3123802.	51072.	0.000	5.307E+10
14.40000	0.61316	3311328.	53130.	0.000	5.307E+10
14.70000	0.57498	3506338.	55230.	0.000	5.307E+10
15.00000	0.53766	3708982.	57371.	0.000	5.307E+10
15.30000	0.50124	3919411.	59555.	0.000	5.307E+10
15.60000	0.46578	4137775.	61780.	0.000	5.307E+10
15.90000	0.43133	4364227.	64047.	0.000	5.307E+10
16.20000	0.39794	4598917.	66357.	0.000	5.307E+10
16.50000	0.36568	4841994.	64855.	-1809.	5.307E+10
16.80000	0.33460	5065873.	58967.	-1790.	5.307E+10
17.10000	0.30476	5266555.	52564.	-1767.	5.307E+10
17.40000	0.27621	5444336.	46249.	-1741.	5.307E+10
17.70000	0.24898	5599551.	40033.	-1712.	5.307E+10
18.00000	0.22312	5732577.	33928.	-1680.	5.307E+10
18.30000	0.19867	5843836.	27947.	-1644.	5.307E+10
18.60000	0.17563	5933792.	22100.	-1604.	5.307E+10
18.90000	0.15405	6002956.	16402.	-1561.	5.307E+10
19.20000	0.13394	6051885.	10865.	-1515.	5.307E+10
19.50000	0.11530	6081184.	5503.	-1464.	5.307E+10
19.80000	0.09815	6091509.	330.64492	-1410.	5.307E+10
20.10000	0.08248	6083565.	-7192.	-2770.	5.307E+10
20.40000	0.06830	6039728.	-17829.	-3140.	5.307E+10
20.70000	0.05559	5955197.	-29800.	-3510.	5.307E+10
21.00000	0.04434	5825171.	-43104.	-3881.	5.307E+10

21.30000	0.03452	5644849.	-57742.	-4251.	5.307E+10
21.60000	0.02607	5409430.	-73508.	-4508.	5.307E+10
21.90000	0.01894	5115588.	-89715.	-4495.	5.307E+10
22.20000	0.01306	4763485.	-105727.	-4400.	5.307E+10
22.50000	0.008342	4354351.	-121219.	-4206.	5.307E+10
22.80000	0.004689	3890709.	-135768.	-3877.	5.307E+10
23.10000	0.001986	3376819.	-148370.	-3124.	5.307E+10
23.40000	0.000108	2822445.	-154316.	-179.40052	5.307E+10
23.70000	-0.001081	2265745.	-151236.	1891.	5.307E+10
24.00000	-0.001716	1733548.	-142156.	3154.	5.307E+10
24.30000	-0.001928	1242221.	-129795.	3713.	5.307E+10
24.60000	-0.001837	799021.	-116452.	3700.	5.307E+10
24.90000	-0.001551	403770.	-103924.	3260.	5.307E+10
25.20000	-0.001166	50767.	-93460.	2553.	5.307E+10
25.50000	-0.000768	-269142.	-59962.	16056.	5.307E+10
25.80000	-0.000437	-380962.	-13338.	9846.	5.307E+10
26.10000	-0.000198	-365176.	12727.	4635.	5.307E+10
26.40000	-4.881E-05	-289327.	23197.	1182.	5.307E+10
26.70000	2.996E-05	-198158.	23973.	-750.78821	5.307E+10
27.00000	6.033E-05	-116719.	19809.	-1563.	5.307E+10
27.30000	6.221E-05	-55532.	14002.	-1663.	5.307E+10
27.60000	5.051E-05	-15903.	8500.	-1393.	5.307E+10
27.90000	3.494E-05	5671.	4205.	-993.03163	5.307E+10
28.20000	2.075E-05	14375.	1325.	-607.21916	5.307E+10
28.50000	1.007E-05	15210.	-314.02728	-303.23604	5.307E+10
28.80000	3.110E-06	12114.	-1033.	-96.23382	5.307E+10
29.10000	-8.952E-07	7772.	-1156.	28.20030	5.307E+10
29.40000	-3.003E-06	3794.	-934.50456	94.59350	5.307E+10
29.70000	-4.184E-06	1043.	-526.99917	131.79839	5.307E+10
30.00000	-5.110E-06	0.000	0.000	160.97892	5.307E+10

Output Summary for Load Case No. 2:

Pile-head deflection	=	2.86300932	inches
Computed slope at pile head	=	-0.01366359	radians
Maximum bending moment	=	6091509.	inch-lbs
Maximum shear force	=	-154316.	lbs
Depth of maximum bending moment	=	19.80000000	feet below pile head
Depth of maximum shear force	=	23.40000000	feet below pile head
Number of iterations	=	23	

Number of zero deflection points = 3

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	1	1.626616	-0.007959	-96875.	3729947.
2	1	2.863009	-0.013664	-154316.	6091509.

Maximum pile-head deflection = 2.8630093196 inches
Maximum pile-head rotation = -0.0136635882 radians = -0.782866 deg.

Summary of Warning Messages

The following warning was reported 276 times

**** Warning ****

An unreasonable input value for shear strength has been specified for a soil defined using the soft clay criteria. The input value is greater than 1250 psf. Please check your input data for correctness.

The following warning was reported 391 times

**** Warning ****

An unreasonable input value for compressive strength has been specified for a soil defined using the weak rock criteria. The input value is less than 100 psi. Please check your input data for correctness.

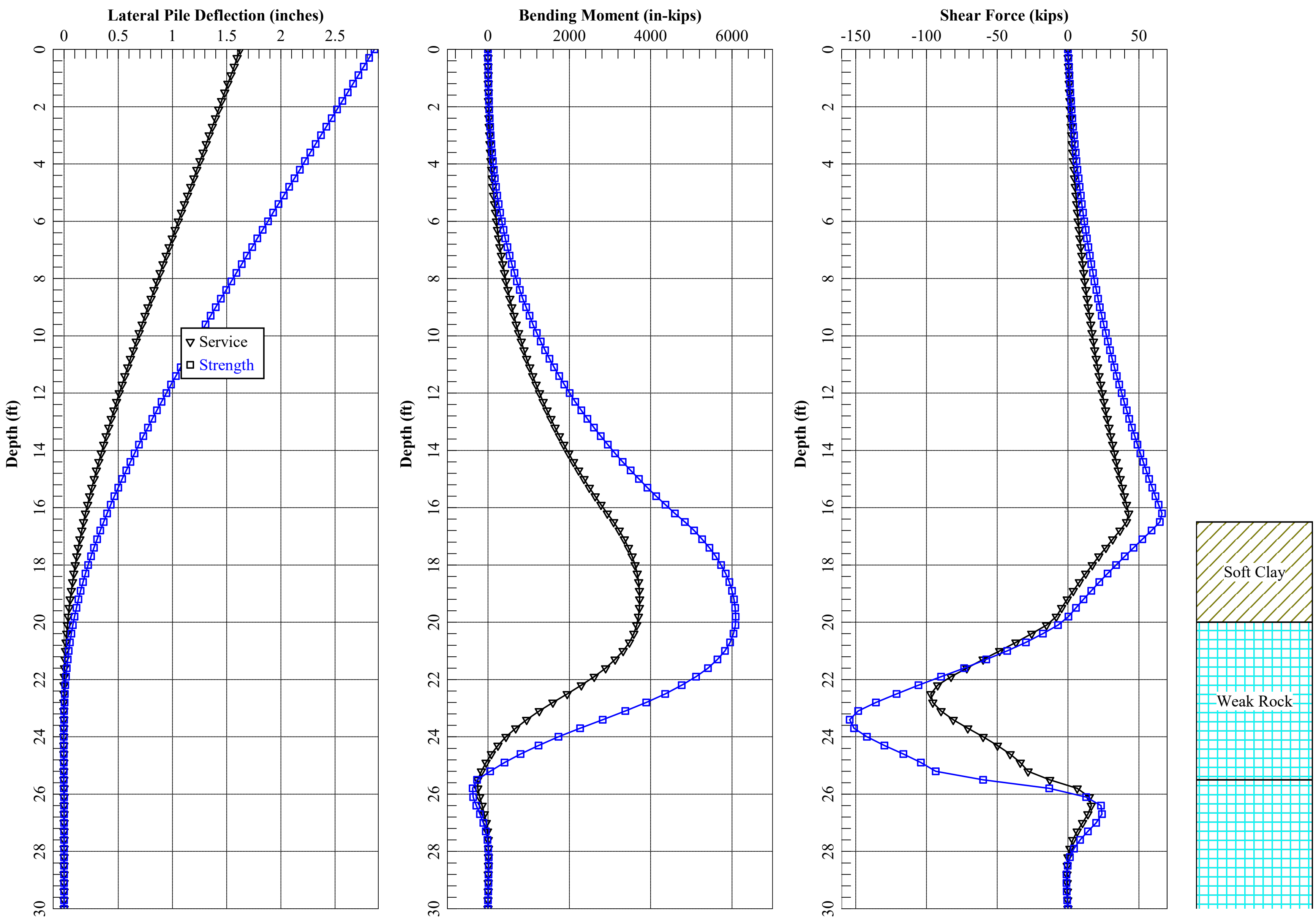
The following warning was reported 345 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.

JAC-35-15.36 Landslide_3ft shaft diameter_5.75ft spacing



Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

Stantec

W24x68 Capacity Checks

CHECK FOR BEAM CLEARANCE

- Chosen beam size: W24x68
- d = 23.7 in
- b_f = 8.97 in
- $\sqrt{23.7^2+8.97^2} = 25.3$ in
- 3-inch clearance for a drilled shaft size of 36 inches = 36in - 2 (3 in) = 30 in
- 25.3 in < 30 in → **ACCEPTABLE**

CHECK FOR DEFLECTION

- Allowable Deflection – 2.0 inches or less recommended
- W24x68 deflection from LPILE is 1.6 inches
- 1.6 in < 2.0 in → **ACCEPTABLE**

CHECK FOR SHEAR CAPACITY OF BEAM

- Section 6 of 8th edition of LRFD Bridge Design Manual
- Chosen beam size: W24x68
  - Maximum Shear from LPILE – 154.3 kips
- $V_n = C\ V_p$

$$V_p = 0.58 F_{yw} D t_w \qquad (6.10.9.3.2\text{-}3)$$

where:

d_o = transverse stiffener spacing (in.)
V_n = nominal shear resistance of the web panel (kip)
V_p = plastic shear force (kip)
C = ratio of the shear-buckling resistance to the shear yield strength

- V_n = 1.0 (0.58 F_{yw} D t_w)
- V_n = 1.0 (0.58) (50 ksi) (23.7 in) (0.415)
- V_n = 285.2 kips > 154.3 kips → **ACCEPTABLE**

Performed by: J. Samples 5/10/2023
Checked by: E. Kistner 5/12/2023

Stantec

CHECK FOR BUCKLING OF BEAM

- Chosen beam size: W24x68

- If $\frac{D}{t_w} \leq 1.12\sqrt{\frac{Ek}{F_{yw}}}$, then:

$$C = 1.0 \qquad (6.10.9.3.2\text{-}4)$$

in which:

k = shear-buckling coefficient

$$= 5 + \frac{5}{\left(\frac{d_o}{D}\right)^2} \qquad (6.10.9.3.2\text{-}7)$$

- $k = 5 + \frac{5}{(\frac{69\text{ in}}{23.7\text{ in}})^2} = 5.5899$
- $1.12\sqrt{\frac{(29{,}000\text{ ksi})\ (5.5899)}{50\text{ ksi}}} = 63.8$
- $\frac{D}{t_w} = \frac{23.7}{0.415} = 57.1 < 63.8 \rightarrow$ **ACCEPTABLE**

CHECK MOMENT CAPACITY

- Chosen beam size: W24x68
  - Unbraced length estimated to be 9 feet
  - Maximum moment from LPILE – 507.6 ft-kips
  - From "Steel Construction Manual", AISC 14th Edition – a W24x68 beam with an unbraced length of 9 feet can support a moment capacity of approximately 612 ft-kips; which is greater than 507.6 ft-kips → **ACCEPTABLE**

===

LPile for Windows, Version 2019-11.001

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

===

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Files Used for Analysis

Path to file locations on this computer:
\\us0268-ppfss01\shared_projects\175578395\technical_production\analysis\Lpile\

Name of the input data file:
JAC-35 design_2.5ft shaft diameter.lp11

Name of the output report file:
JAC-35 design_2.5ft shaft diameter.lp11

Name of the plot output file:
JAC-35 design_2.5ft shaft diameter.lp11

Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

Name of the runtime message file:
JAC-35 design_2.5ft shaft diameter.lp11

Date and Time of Analysis

Date: May 18, 2023   Time: 9:39:44

Problem Title

Project Name: JAC-35-15.36

Job Number: 175578395

Client: ODOT

Engineer: J. Samples

Description: Landslide Remediation

Program Options and Settings

Computational Options:
 - Use unfactored loads in computations (conventional analysis)

Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

```
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - Analysis includes loading by multiple distributed lateral loads acting on pile
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using narrow report formats
   (Note: Some output information is omitted from the narrow report formats)



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =            2
Total length of pile                                   =       30.000 ft
```

Depth of ground surface below top of pile = 16.5000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	8.2200
2	9.000	8.2200
3	9.000	30.0000
4	30.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile
Length of section = 9.000000 ft
AISC Section Type = W

AISC Section Name = W21X55

Pile width = 8.220000 in
Shear capacity of section = 0.0000 lbs

Pile Section No. 2:

Section 2 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 21.000000 ft
Width of top of section = 30.000000 in
Width of bottom of section = 30.000000 in

```
   Top Area                                          =    16.200000 sq. in
   Bottom Area                                       =    16.200000 sq. in
   Moment of Inertia at Top                          =        1140. in^4
   Moment of Inertia at Bottom                       =        1140. in^4
   Elastic Modulus                                   =    29000000. psi
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                   =        0.000 degrees
                                                     =        0.000 radians

Pile Batter Angle                                    =        0.000 degrees
                                                     =        0.000 radians
```

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is soft clay, p-y criteria by Matlock, 1970

```
   Distance from top of pile to top of layer         =    16.500000 ft
   Distance from top of pile to bottom of layer      =    20.000000 ft
   Effective unit weight at top of layer             =   133.000000 pcf
   Effective unit weight at bottom of layer          =   133.000000 pcf
   Undrained cohesion at top of layer                =        6000. psf
   Undrained cohesion at bottom of layer             =        6000. psf
   Epsilon-50 at top of layer                        =       0.0000
   Epsilon-50 at bottom of layer                     =       0.0000
```

NOTE: Default values for Epsilon-50 will be computed for this layer.

```
Layer 2 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    20.000000 ft
   Distance from top of pile to bottom of layer       =    24.000000 ft
   Effective unit weight at top of layer              =   145.000000 pcf
   Effective unit weight at bottom of layer           =   145.000000 pcf
   Uniaxial compressive strength at top of layer      =    73.500000 psi
   Uniaxial compressive strength at bottom of layer   =    73.500000 psi
   Initial modulus of rock at top of layer            =        6615. psi
   Initial modulus of rock at bottom of layer         =        6615. psi
   RQD of rock at top of layer                        =       0.0000 %
   RQD of rock at bottom of layer                     =       0.0000 %
   k rm of rock at top of layer                       =    0.0000500
   k rm of rock at bottom of layer                    =    0.0000500


Layer 3 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    24.000000 ft
   Distance from top of pile to bottom of layer       =    25.500000 ft
   Effective unit weight at top of layer              =    82.600000 pcf
   Effective unit weight at bottom of layer           =    82.600000 pcf
   Uniaxial compressive strength at top of layer      =    73.500000 psi
   Uniaxial compressive strength at bottom of layer   =    73.500000 psi
   Initial modulus of rock at top of layer            =        6615. psi
   Initial modulus of rock at bottom of layer         =        6615. psi
   RQD of rock at top of layer                        =       0.0000 %
   RQD of rock at bottom of layer                     =       0.0000 %
   k rm of rock at top of layer                       =    0.0000500
   k rm of rock at bottom of layer                    =    0.0000500


Layer 4 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    25.500000 ft
   Distance from top of pile to bottom of layer       =    40.000000 ft
   Effective unit weight at top of layer              =   145.000000 pcf
   Effective unit weight at bottom of layer           =   145.000000 pcf
   Uniaxial compressive strength at top of layer      =   700.000000 psi
   Uniaxial compressive strength at bottom of layer   =   700.000000 psi
```

```
   Initial modulus of rock at top of layer             =       63000. psi
   Initial modulus of rock at bottom of layer          =       63000. psi
   RQD of rock at top of layer                         =    30.000000 %
   RQD of rock at bottom of layer                      =    30.000000 %
   k rm of rock at top of layer                        =    0.0000500
   k rm of rock at bottom of layer                     =    0.0000500
```

(Depth of the lowest soil layer extends 10.000 ft below the pile tip)

----

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 4 points

Point No.	Depth X ft	p-mult	y-mult
1	16.500	0.8000	1.0000
2	20.000	0.8000	1.0000
3	20.000	1.0000	1.0000
4	40.000	1.0000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 4 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	33.000
2	90.000	156.700
3	90.000	163.900
4	198.000	356.200

Distributed lateral load intensity for Load Case 2 defined using 4 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	57.700
2	90.000	243.300
3	90.000	255.800
4	198.000	544.300

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000
2	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000

V = shear force applied normal to pile axis
M = bending moment applied to pile head

y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Steel AISC Strong Axis:

Length of Section	=	9.000000 ft
Flange Width	=	8.220000 in
Section Depth	=	20.800000 in
Flange Thickness	=	0.522000 in
Web Thickness	=	0.375000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	16.200000 sq. in.
Moment of Inertia	=	1140. in^4
Elastic Bending Stiffness	=	33060000. kip-in^2
Plastic Modulus, Z	=	126.000000in^3
Plastic Moment Capacity = Fy Z	=	6300.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	810.000 kips

Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

Nominal Axial Tensile Capacity = -810.000 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000089143	289.9547853743	32526787.	10.4000000000	
0.0000178287	579.9095707486	32526787.	10.4000000000	
0.0000267430	869.8643561229	32526787.	10.4000000000	
0.0000356574	1160.	32526787.	10.4000000000	
0.0000445717	1450.	32526787.	10.4000000000	
0.0000534860	1740.	32526787.	10.4000000000	
0.0000624004	2030.	32526787.	10.4000000000	
0.0000713147	2320.	32526787.	10.4000000000	
0.0000802290	2610.	32526787.	10.4000000000	
0.0000891434	2900.	32526787.	10.4000000000	
0.0000980577	3190.	32526787.	10.4000000000	
0.0001069721	3479.	32526787.	10.4000000000	
0.0001158864	3769.	32526787.	10.4000000000	
0.0001248007	4059.	32526787.	10.4000000000	
0.0001337151	4349.	32526787.	10.4000000000	
0.0001426294	4639.	32526787.	10.4000000000	
0.0001515438	4929.	32526787.	10.4000000000	

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Checked by: Eric Kistner 5/12/2023

0.0001604581	5219.	32526787.	10.4000000000	
0.0001693724	5489.	32407907.	10.4000000000	Y
0.0001782868	5591.	31361448.	10.4000000000	Y
0.0001872011	5646.	30157616.	10.4000000000	Y
0.0001961154	5693.	29026956.	10.4000000000	Y
0.0002050298	5734.	27965780.	10.4000000000	Y
0.0002139441	5770.	26968649.	10.4000000000	Y
0.0002228585	5802.	26032603.	10.4000000000	Y
0.0002317728	5830.	25153172.	10.4000000000	Y
0.0002406871	5855.	24326511.	10.4000000000	Y
0.0002496015	5877.	23547363.	10.4000000000	Y
0.0002585158	5898.	22813444.	10.4000000000	Y
0.0002674302	5916.	22121129.	10.4000000000	Y
0.0002763445	5932.	21467215.	10.4000000000	Y
0.0002852588	5947.	20848847.	10.4000000000	Y
0.0002941732	5961.	20263469.	10.4000000000	Y
0.0003030875	5973.	19708782.	10.4000000000	Y
0.0003120018	5985.	19182351.	10.4000000000	Y
0.0003209162	5995.	18681690.	10.4000000000	Y
0.0003298305	6005.	18205920.	10.4000000000	Y
0.0003387449	6014.	17753489.	10.4000000000	Y
0.0003476592	6022.	17321387.	10.4000000000	Y
0.0003654879	6037.	16516645.	10.4000000000	Y
0.0003833166	6049.	15781478.	10.4000000000	Y
0.0004011452	6060.	15107419.	10.4000000000	Y
0.0004189739	6070.	14487375.	10.4000000000	Y
0.0004368026	6078.	13915347.	10.4000000000	Y
0.0004546313	6086.	13386215.	10.4000000000	Y
0.0004724599	6093.	12895422.	10.4000000000	Y
0.0004902886	6098.	12438291.	10.4000000000	Y
0.0005081173	6104.	12012494.	10.4000000000	Y
0.0005259460	6109.	11614341.	10.4000000000	Y
0.0005437746	6113.	11241518.	10.4000000000	Y
0.0005616033	6117.	10891627.	10.4000000000	Y
0.0005794320	6120.	10562716.	10.4000000000	Y
0.0005972607	6124.	10252748.	10.4000000000	Y
0.0006150894	6127.	9960687.	10.4000000000	Y
0.0006329180	6129.	9684136.	10.4000000000	Y
0.0006507467	6132.	9422738.	10.4000000000	Y
0.0006685754	6134.	9175033.	10.4000000000	Y

Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

0.0006864041	6136.	8939644.	10.4000000000	Y
0.0007042327	6138.	8716173.	10.4000000000	Y
0.0007220614	6140.	8503692.	10.4000000000	Y
0.0007398901	6142.	8300872.	10.4000000000	Y
0.0007577188	6143.	8107596.	10.4000000000	Y
0.0007755474	6145.	7923207.	10.4000000000	Y
0.0007933761	6146.	7746998.	10.4000000000	Y
0.0008112048	6147.	7578164.	10.4000000000	Y
0.0008290335	6149.	7416592.	10.4000000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	6149.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	16.5000	0.00	N.A.	No	0.00	178483.
2	20.0000	3.5000	No	Yes	N.A.	N.A.
3	24.0000	7.5000	No	Yes	N.A.	N.A.
4	25.5000	9.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness in-lb^2

0.000	2.03288	5.573E-06	0.000	0.000	3.253E+10
0.30000	1.99660	221.85578	129.93300	0.000	3.253E+10
0.60000	1.96032	935.51761	275.45220	0.000	3.253E+10
0.90000	1.92404	2205.	438.78420	0.000	3.253E+10
1.20000	1.88776	4095.	619.92900	0.000	3.253E+10
1.50000	1.85149	6669.	818.88660	0.000	3.253E+10
1.80000	1.81521	9991.	1036.	0.000	3.253E+10
2.10000	1.77894	14125.	1270.	0.000	3.253E+10
2.40000	1.74268	19136.	1523.	0.000	3.253E+10
2.70000	1.70642	25088.	1793.	0.000	3.253E+10
3.00000	1.67017	32045.	2081.	0.000	3.253E+10
3.30000	1.63394	40071.	2387.	0.000	3.253E+10
3.60000	1.59772	49229.	2710.	0.000	3.253E+10
3.90000	1.56152	59585.	3052.	0.000	3.253E+10
4.20000	1.52535	71202.	3411.	0.000	3.253E+10
4.50000	1.48920	84145.	3788.	0.000	3.253E+10
4.80000	1.45309	98477.	4183.	0.000	3.253E+10
5.10000	1.41701	114263.	4596.	0.000	3.253E+10
5.40000	1.38099	131567.	5026.	0.000	3.253E+10
5.70000	1.34501	150452.	5475.	0.000	3.253E+10
6.00000	1.30909	170984.	5941.	0.000	3.253E+10
6.30000	1.27325	193226.	6425.	0.000	3.253E+10
6.60000	1.23748	217242.	6927.	0.000	3.253E+10
6.90000	1.20179	243097.	7446.	0.000	3.253E+10
7.20000	1.16620	270854.	7984.	0.000	3.253E+10
7.50000	1.13073	300578.	8546.	0.000	3.253E+10
7.80000	1.09537	332382.	9141.	0.000	3.253E+10
8.10000	1.06014	366393.	9766.	0.000	3.253E+10
8.40000	1.02506	402694.	10413.	0.000	3.253E+10
8.70000	0.99014	441369.	11084.	0.000	3.253E+10
9.00000	0.95539	482500.	11778.	0.000	3.253E+10
9.30000	0.92084	526171.	12495.	0.000	3.306E+10
9.60000	0.88649	572464.	13235.	0.000	3.306E+10
9.90000	0.85237	621463.	13998.	0.000	3.306E+10
10.20000	0.81849	673251.	14784.	0.000	3.306E+10
10.50000	0.78488	727910.	15594.	0.000	3.306E+10
10.80000	0.75155	785525.	16426.	0.000	3.306E+10
11.10000	0.71853	846177.	17281.	0.000	3.306E+10
11.40000	0.68584	909950.	18160.	0.000	3.306E+10
11.70000	0.65351	976928.	19061.	0.000	3.306E+10

12.00000	0.62156	1047192.	19986.	0.000	3.306E+10
12.30000	0.59002	1120827.	20934.	0.000	3.306E+10
12.60000	0.55892	1197915.	21905.	0.000	3.306E+10
12.90000	0.52829	1278540.	22898.	0.000	3.306E+10
13.20000	0.49816	1362784.	23915.	0.000	3.306E+10
13.50000	0.46856	1450731.	24955.	0.000	3.306E+10
13.80000	0.43954	1542463.	26018.	0.000	3.306E+10
14.10000	0.41112	1638064.	27105.	0.000	3.306E+10
14.40000	0.38334	1737616.	28214.	0.000	3.306E+10
14.70000	0.35624	1841204.	29346.	0.000	3.306E+10
15.00000	0.32986	1948909.	30502.	0.000	3.306E+10
15.30000	0.30425	2060816.	31680.	0.000	3.306E+10
15.60000	0.27945	2177006.	32882.	0.000	3.306E+10
15.90000	0.25549	2297564.	34106.	0.000	3.306E+10
16.20000	0.23244	2422571.	35354.	0.000	3.306E+10
16.50000	0.21034	2552112.	33904.	-1333.	3.306E+10
16.80000	0.18924	2666681.	29458.	-1315.	3.306E+10
17.10000	0.16919	2764207.	24761.	-1294.	3.306E+10
17.40000	0.15022	2844957.	20144.	-1271.	3.306E+10
17.70000	0.13236	2909242.	15619.	-1243.	3.306E+10
18.00000	0.11565	2957412.	11197.	-1213.	3.306E+10
18.30000	0.10009	2989862.	6892.	-1179.	3.306E+10
18.60000	0.08571	3007032.	2715.	-1142.	3.306E+10
18.90000	0.07250	3009407.	-1321.	-1100.	3.306E+10
19.20000	0.06048	2997521.	-5201.	-1055.	3.306E+10
19.50000	0.04962	2971957.	-8912.	-1006.	3.306E+10
19.80000	0.03994	2933351.	-12440.	-953.11182	3.306E+10
20.10000	0.03140	2882393.	-18346.	-2329.	3.306E+10
20.40000	0.02400	2801256.	-27396.	-2699.	3.306E+10
20.70000	0.01769	2685142.	-37373.	-2844.	3.306E+10
21.00000	0.01244	2532169.	-47746.	-2919.	3.306E+10
21.30000	0.008174	2341371.	-58239.	-2911.	3.306E+10
21.60000	0.004830	2112849.	-68519.	-2800.	3.306E+10
21.90000	0.002314	1848036.	-78124.	-2536.	3.306E+10
22.20000	0.000522	1550354.	-84041.	-750.75047	3.306E+10
22.50000	-0.000662	1242942.	-83554.	1021.	3.306E+10
22.80000	-0.001358	948765.	-77684.	2240.	3.306E+10
23.10000	-0.001683	683619.	-68335.	2954.	3.306E+10
23.40000	-0.001739	456752.	-57192.	3237.	3.306E+10
23.70000	-0.001617	271836.	-45641.	3180.	3.306E+10

24.00000	-0.001388	128138.	-34738.	2877.	3.306E+10
24.30000	-0.001109	21724.	-25211.	2416.	3.306E+10
24.60000	-0.000821	-53385.	-17488.	1876.	3.306E+10
24.90000	-0.000554	-104186.	-11727.	1325.	3.306E+10
25.20000	-0.000328	-137819.	-7868.	819.37638	3.306E+10
25.50000	-0.000156	-160833.	580.27774	3874.	3.306E+10
25.80000	-4.744E-05	-133641.	9756.	1223.	3.306E+10
26.10000	9.054E-06	-90593.	11521.	-242.62396	3.306E+10
26.40000	3.004E-05	-50689.	9581.	-835.20213	3.306E+10
26.70000	3.115E-05	-21610.	6462.	-897.56167	3.306E+10
27.00000	2.379E-05	-4163.	3569.	-709.54832	3.306E+10
27.30000	1.480E-05	4089.	1471.	-456.39313	3.306E+10
27.60000	7.417E-06	6425.	228.46209	-233.64735	3.306E+10
27.90000	2.549E-06	5733.	-336.62835	-80.29179	3.306E+10
28.20000	-7.190E-08	4001.	-477.07699	2.26476	3.306E+10
28.50000	-1.124E-06	2298.	-409.25932	35.41172	3.306E+10
28.80000	-1.275E-06	1055.	-273.20135	40.17604	3.306E+10
29.10000	-1.013E-06	331.42564	-143.43286	31.91757	3.306E+10
29.40000	-6.212E-07	21.89319	-50.76155	19.56649	3.306E+10
29.70000	-2.205E-07	-34.05749	-3.04072	6.94508	3.306E+10
30.00000	1.669E-07	0.000	0.000	-5.25579	3.306E+10

Output Summary for Load Case No. 1:

```
Pile-head deflection              =     2.03287958 inches
Computed slope at pile head       =    -0.01007772 radians
Maximum bending moment            =       3009407. inch-lbs
Maximum shear force               =        -84041. lbs
Depth of maximum bending moment   =    18.90000000 feet below pile head
Depth of maximum shear force      =    22.20000000 feet below pile head
Number of iterations              =             21
Number of zero deflection points =              4
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness in-lb^2
0.000	3.57246	1.783E-05	0.000	0.000	3.253E+10
0.30000	3.51025	385.92290	224.42400	0.000	3.253E+10
0.60000	3.44803	1616.	472.23360	0.000	3.253E+10
0.90000	3.38581	3786.	746.76960	0.000	3.253E+10
1.20000	3.32360	6993.	1048.	0.000	3.253E+10
1.50000	3.26139	11332.	1376.	0.000	3.253E+10
1.80000	3.19918	16900.	1731.	0.000	3.253E+10
2.10000	3.13698	23793.	2112.	0.000	3.253E+10
2.40000	3.07478	32108.	2520.	0.000	3.253E+10
2.70000	3.01261	41940.	2955.	0.000	3.253E+10
3.00000	2.95044	53385.	3417.	0.000	3.253E+10
3.30000	2.88830	66541.	3905.	0.000	3.253E+10
3.60000	2.82619	81503.	4420.	0.000	3.253E+10
3.90000	2.76411	98367.	4962.	0.000	3.253E+10
4.20000	2.70206	117230.	5531.	0.000	3.253E+10
4.50000	2.64007	138187.	6126.	0.000	3.253E+10
4.80000	2.57813	161336.	6748.	0.000	3.253E+10
5.10000	2.51625	186772.	7397.	0.000	3.253E+10
5.40000	2.45445	214591.	8072.	0.000	3.253E+10
5.70000	2.39273	244890.	8774.	0.000	3.253E+10
6.00000	2.33111	277765.	9503.	0.000	3.253E+10
6.30000	2.26960	313312.	10259.	0.000	3.253E+10
6.60000	2.20822	351627.	11041.	0.000	3.253E+10
6.90000	2.14697	392807.	11850.	0.000	3.253E+10
7.20000	2.08589	436947.	12686.	0.000	3.253E+10
7.50000	2.02497	484145.	13560.	0.000	3.253E+10
7.80000	1.96425	534580.	14488.	0.000	3.253E+10
8.10000	1.90375	588455.	15460.	0.000	3.253E+10
8.40000	1.84347	645894.	16468.	0.000	3.253E+10
8.70000	1.78346	707023.	17510.	0.000	3.253E+10

9.00000	1.72373	771965.	18586.	0.000	3.253E+10
9.30000	1.66430	840845.	19698.	0.000	3.306E+10
9.60000	1.60520	913789.	20844.	0.000	3.306E+10
9.90000	1.54647	990920.	22024.	0.000	3.306E+10
10.20000	1.48812	1072363.	23239.	0.000	3.306E+10
10.50000	1.43019	1158243.	24489.	0.000	3.306E+10
10.80000	1.37271	1248685.	25774.	0.000	3.306E+10
11.10000	1.31573	1343813.	27093.	0.000	3.306E+10
11.40000	1.25927	1443751.	28446.	0.000	3.306E+10
11.70000	1.20337	1548625.	29834.	0.000	3.306E+10
12.00000	1.14809	1658559.	31257.	0.000	3.306E+10
12.30000	1.09345	1773677.	32715.	0.000	3.306E+10
12.60000	1.03951	1894105.	34207.	0.000	3.306E+10
12.90000	0.98631	2019967.	35734.	0.000	3.306E+10
13.20000	0.93391	2151387.	37295.	0.000	3.306E+10
13.50000	0.88234	2288491.	38891.	0.000	3.306E+10
13.80000	0.83168	2431402.	40522.	0.000	3.306E+10
14.10000	0.78197	2580245.	42187.	0.000	3.306E+10
14.40000	0.73327	2735146.	43887.	0.000	3.306E+10
14.70000	0.68564	2896229.	45621.	0.000	3.306E+10
15.00000	0.63914	3063617.	47390.	0.000	3.306E+10
15.30000	0.59385	3237437.	49194.	0.000	3.306E+10
15.60000	0.54983	3417813.	51032.	0.000	3.306E+10
15.90000	0.50714	3604868.	52905.	0.000	3.306E+10
16.20000	0.46587	3798729.	54813.	0.000	3.306E+10
16.50000	0.42609	3999519.	53228.	-1686.	3.306E+10
16.80000	0.38788	4181968.	47674.	-1670.	3.306E+10
17.10000	0.35131	4342769.	41694.	-1651.	3.306E+10
17.40000	0.31643	4482168.	35790.	-1629.	3.306E+10
17.70000	0.28332	4600460.	29974.	-1602.	3.306E+10
18.00000	0.25201	4697984.	24259.	-1573.	3.306E+10
18.30000	0.22254	4775128.	18659.	-1539.	3.306E+10
18.60000	0.19494	4832328.	13187.	-1501.	3.306E+10
18.90000	0.16924	4870071.	7857.	-1460.	3.306E+10
19.20000	0.14545	4888897.	2684.	-1414.	3.306E+10
19.50000	0.12357	4889397.	-2316.	-1364.	3.306E+10
19.80000	0.10361	4872219.	-7129.	-1310.	3.306E+10
20.10000	0.08556	4838069.	-13678.	-2329.	3.306E+10
20.40000	0.06940	4773741.	-22727.	-2699.	3.306E+10
20.70000	0.05512	4674434.	-33110.	-3069.	3.306E+10

21.00000	0.04267	4535348.	-44827.	-3440.	3.306E+10
21.30000	0.03200	4351681.	-57877.	-3810.	3.306E+10
21.60000	0.02303	4118632.	-72184.	-4138.	3.306E+10
21.90000	0.01568	3831955.	-86998.	-4092.	3.306E+10
22.20000	0.009830	3492249.	-101450.	-3937.	3.306E+10
22.50000	0.005350	3101513.	-115083.	-3636.	3.306E+10
22.80000	0.002085	2663649.	-127163.	-3075.	3.306E+10
23.10000	-0.000136	2185939.	-132269.	237.86766	3.306E+10
23.40000	-0.001499	1711312.	-126819.	2790.	3.306E+10
23.70000	-0.002192	1272842.	-115095.	3724.	3.306E+10
24.00000	-0.002386	882631.	-101172.	4011.	3.306E+10
24.30000	-0.002234	544407.	-86480.	4150.	3.306E+10
24.60000	-0.001868	259973.	-71513.	4165.	3.306E+10
24.90000	-0.001400	29514.	-57991.	3347.	3.306E+10
25.20000	-0.000921	-157564.	-47827.	2300.	3.306E+10
25.50000	-0.000504	-314838.	-21206.	12489.	3.306E+10
25.80000	-0.000210	-310250.	11027.	5418.	3.306E+10
26.10000	-3.782E-05	-235444.	22604.	1013.	3.306E+10
26.40000	4.216E-05	-147504.	22318.	-1172.	3.306E+10
26.70000	6.433E-05	-74757.	16871.	-1853.	3.306E+10
27.00000	5.718E-05	-26030.	10466.	-1705.	3.306E+10
27.30000	3.983E-05	598.14872	5187.	-1228.	3.306E+10
27.60000	2.272E-05	11313.	1688.	-715.58837	3.306E+10
27.90000	1.004E-05	12753.	-168.99113	-316.16844	3.306E+10
28.20000	2.356E-06	10096.	-871.70498	-74.22814	3.306E+10
28.50000	-1.366E-06	6477.	-927.83629	43.04408	3.306E+10
28.80000	-2.550E-06	3415.	-705.74675	80.33900	3.306E+10
29.10000	-2.396E-06	1395.	-425.31082	75.45874	3.306E+10
29.40000	-1.694E-06	353.18196	-193.45808	53.34834	3.306E+10
29.70000	-8.532E-07	2.43009	-49.05305	26.87668	3.306E+10
30.00000	-1.191E-08	0.000	0.000	0.37501	3.306E+10

Output Summary for Load Case No. 2:

```
Pile-head deflection              =     3.57246480 inches
Computed slope at pile head       =    -0.01728266 radians
Maximum bending moment            =       4889397. inch-lbs
Maximum shear force               =       -132269. lbs
Depth of maximum bending moment   =    19.50000000 feet below pile head
Depth of maximum shear force      =    23.10000000 feet below pile head
```


Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

Number of iterations = 25
Number of zero deflection points = 4

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	1	2.032880	-0.010078	-84041.	3009407.
2	1	3.572465	-0.017283	-132269.	4889397.

Maximum pile-head deflection = 3.5724647956 inches
Maximum pile-head rotation = -0.0172826569 radians = -0.990223 deg.

Summary of Warning Messages

The following warning was reported 300 times

**** Warning ****

An unreasonable input value for shear strength has been specified for a soil defined using the soft clay criteria. The input value is greater than 1250 psf. Please check your input data for correctness.

The following warning was reported 425 times

**** Warning ****

An unreasonable input value for compressive strength has been specified for a soil defined using the weak rock criteria. The input value is less than 100 psi. Please check your input data for correctness.

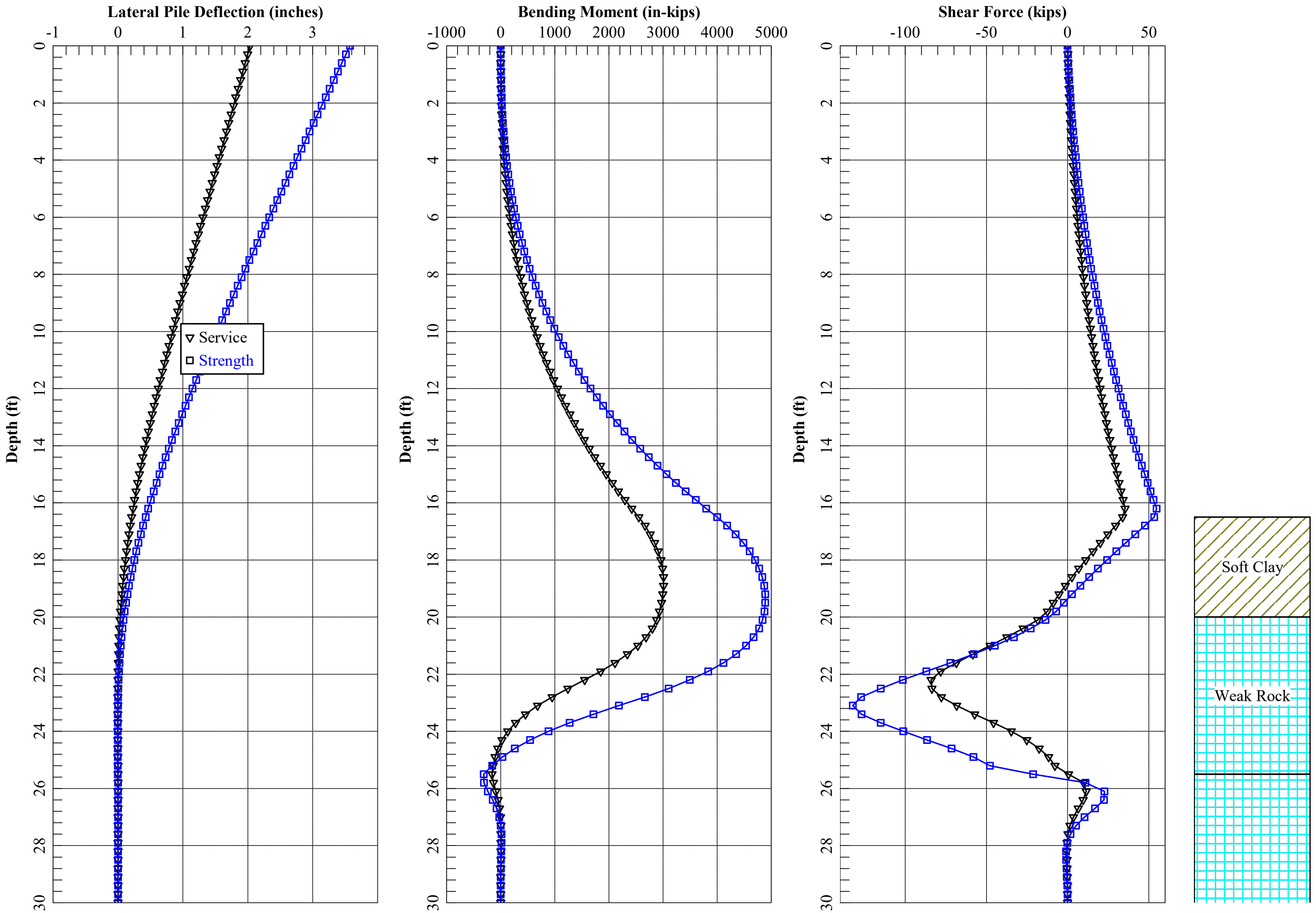
The following warning was reported 375 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.

JAC-35-15.36 Landslide_2.5ft shaft diameter_4.75ft spacing



Performed by: James Samples 5/10/2023
Checked by: Eric Kistner 5/12/2023

Stantec

W21x55 Capacity Checks

CHECK FOR BEAM CLEARANCE

- Chosen beam size: W21x55
- d = 20.8 in
- b_f = 8.22 in
- $\sqrt{20.8^2+8.22^2} = 22.4$ in
- 3-inch clearance for a drilled shaft size of 30 inches = 30in - 2 (3 in) = 24 in
- 22.4 in < 24 in → **ACCEPTABLE**

CHECK FOR DEFLECTION

- Allowable Deflection – 2.0 inches or less recommended
- W21x55 deflection from LPILE is 2.0 inches
- 2.0 in = 2.0 in → **ACCEPTABLE**

CHECK FOR SHEAR CAPACITY OF BEAM

- Section 6 of 8th edition of LRFD Bridge Design Manual
- Chosen beam size: W21x55
  - Maximum Shear from LPILE – 132.3 kips
- $V_n = C\ V_p$

$$V_p = 0.58 F_{yw} D t_w \qquad (6.10.9.3.2\text{-}3)$$

where:

d_o = transverse stiffener spacing (in.)
V_n = nominal shear resistance of the web panel (kip)
V_p = plastic shear force (kip)
C = ratio of the shear-buckling resistance to the shear yield strength

- $V_n = 1.0\ (0.58\ F_{yw}\ D\ t_w)$
- V_n = 1.0 (0.58) (50 ksi) (20.8 in) (0.375)
- V_n = 226.2 kips > 132.3 kips → **ACCEPTABLE**

Performed by: J. Samples 5/10/2023
Checked by: E. Kistner 5/12/2023

CHECK FOR BUCKLING OF BEAM

- Chosen beam size: W21x55

- If $\frac{D}{t_w} \leq 1.12\sqrt{\frac{Ek}{F_{yw}}}$, then:

  $C = 1.0$ (6.10.9.3.2-4)

in which:

k = shear-buckling coefficient

$$= 5 + \frac{5}{\left(\frac{d_o}{D}\right)^2} \qquad (6.10.9.3.2\text{-}7)$$

- $k = 5 + \frac{5}{(\frac{57\text{ in}}{20.8\text{ in}})^2} = 5.6658$
- $1.12\sqrt{\frac{(29{,}000\text{ ksi})\ (5.6658)}{50\text{ ksi}}} = 64.2$
- $\frac{D}{t_w} = \frac{20.8}{0.375} = 55.5 < 64.2 \rightarrow$ **ACCEPTABLE**

CHECK MOMENT CAPACITY

- Chosen beam size: W21x55
  - Unbraced length estimated to be 9 feet
  - Maximum moment from LPILE – 407.4 ft-kips
  - From "Steel Construction Manual", AISC 14th Edition – a W21x55 beam with an unbraced length of 9 feet can support a moment capacity of approximately 425 ft-kips; which is greater than 407.4 ft-kips → **ACCEPTABLE**

APPENDIX D
GEOTECHNICAL DESIGN CHECKLISTS

I. Geotechnical Design Checklists

Project:	**JAC-35-15.36**	**PDP Path:**	**N/A**
PID:	**116242**	**Review Stage:**	**Final**

Checklist	**Included in This Submission**
II. Reconnaissance and Planning	✓
III. A. Centerline Cuts	
III. B. Embankments	
III. C. Subgrade	
IV. A. Foundations of Structures	
IV. B. Retaining Wall	
V. A. Landslide Remediation	✓
V. B. Rockfall Remediation	
V. C. Wetland or Peat Remediation	
V. D. Underground Mine Remediation	
V. E. Surface Mine Remediation	
V. F. Karst Remediation	
VI. A. Geotechnical Profile	✓
VI. D. Geotechnical Reports	✓

II. Reconnaissance and Planning Checklist

C-R-S: JAC-35-15.36	PID: 116242	Reviewer: James Samples	Date: 5/11/2023

Reconnaissance		(Y/N/X)	Notes:
1	Based on Section 302.1 in the SGE, have the necessary plans been developed in the following areas prior to the commencement of the subsurface exploration reconnaissance:	Y	
	Roadway plans	✓	
	Structures plans		
	Geohazards plans	✓	
2	Have the resources listed in Section 302.2.1 of the SGE been reviewed as part of the office reconnaissance?	Y	
3	Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance?	Y	
4	If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded?	X	

Planning - General		(Y/N/X)	Notes:
5	In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and historic subsurface exploration work been considered?	Y	
6	Has the ODOT Transportation Information Mapping System (TIMS) been accessed to find all available historic boring information and inventoried geohazards?	Y	
7	Have the borings been located to develop the maximum subsurface information while using a minimum number of borings, utilizing historic geotechnical explorations to the fullest extent possible?	Y	
8	Have the topography, geologic origin of materials, surface manifestation of soil conditions, and any other special design considerations been utilized in determining the spacing and depth of borings?	Y	
9	Have the borings been located so as to provide adequate overhead clearance for the equipment, clearance of underground utilities, minimize damage to private property, and minimize disruption of traffic, without compromising the quality of the exploration?	Y	

II. Reconnaissance and Planning Checklist

Planning - General		(Y/N/X)	Notes:
10	Have the scaled boring plans, showing all project and historic borings, and a schedule of borings in tabular format, been submitted to the District Geotechnical Engineer?	Y	
	The schedule of borings should present the following information for each boring:		
a.	exploration identification number	Y	
b.	location by station and offset	Y	Estimated from historic projects
c.	estimated amount of rock and soil, including the total for each for the entire program.	Y	
Planning – Exploration Number		(Y/N/X)	Notes:
11	Have the coordinates, stations and offsets of all explorations (borings, soundings, test pits, etc.) been identified?	Y	
12	Has each exploration been assigned a unique identification number, in the following format X-ZZZ-W-YY, as per Section 303.2 of the SGE?	Y	
13	When referring to historic explorations that did not use the identification scheme in 12 above, have the historic explorations been assigned identification numbers according to Section 303.2 of the SGE?	Y	

II. Reconnaissance and Planning Checklist

Planning – Boring Types		(Y/N/X)	Notes:
14	Based on Sections 303.3 to 303.7.6 of the SGE, have the location, depth, and sampling requirements for the following boring types been determined for the project?	Y	
	Check all boring types utilized for this project:		
	Existing Subgrades (Type A)		
	Roadway Borings (Type B)		
	Embankment Foundations (Type B1)		
	Cut Sections (Type B2)		
	Sidehill Cut Sections (Type B3)		
	Sidehill Cut-Fill Sections (Type B4)		
	Sidehill Fill Sections on Unstable Slopes (Type B5)		
	Geohazard Borings (Type C)	✓	
	Lakes, Ponds, and Low-Lying Areas (Type C1)		
	Peat Deposits, Compressible Soils, and Low Strength Soils (Type C2)		
	Uncontrolled Fills, Waste Pits, and Reclaimed Surface Mines (Type C3)		
	Underground Mines (C4)		
	Landslides (Type C5)		
	Rock Slope (Type C6)		
	Karst (Type C7)		
	Proposed Underground Utilities (Type D)		
	Structure Borings (Type E)		
	Bridges (Type E1)		
	Culverts (Type E2 a,b,c)		
	Retaining Walls (Type E3 a and b)		
	Noise Barrier (Type E4)		
	CCTV & High Mast Lighting Towers (Type E5)		
	Buildings and Salt Domes (Type E6)		

V.A. Landslide Remediation Checklist

C-R-S:	JAC-35-15.36	PID:	116242	Reviewer:	James Samples	Date:	5/11/2023

If you do not have a landslide remediation on the project, you do not have to fill out this checklist.

Exploration		(Y/N/X)	Notes:
1	Is the site included in the GHMS/ Collector Landslide Inventory? If yes, provide the rating.	Y	Tier 3
2	Has a site reconnaissance been conducted to define the limits of the landslide?	Y	
	If yes, check the visible signs observed:		
	cracks in pavement	✓	
	bulging toe		
	sloughed slopes	✓	
	scarp		
	stream channel or ditch pinches		
	hydrophytic vegetation		
	rotated or dropped guardrail	✓	
	bent, cracked, or crushed pipe, culvert, or other structures		
	water seepage, flow from embankment, or ice		
	leaning, curved, J-shaped, deformed, or fallen trees or power poles		
	deflection of linear features	✓	
	other (describe other visible signs)		
3	Have a site plan and cross sections been provided to compare ground surface conditions before and after failure?	N	
4	Has the history of the landslide area been researched, including movement history, maintenance work, pavement drainage, and past corrective measures?	Y	
5	Has a site specific geotechnical exploration been performed to investigate the landslide area?	Y	
6	Has a groundwater monitoring program been performed to identify the phreatic surface through the landslide area?	N	
7	Has a landslide failure plane been determined from field observations or instrumentation?	N	

V.A. Landslide Remediation Checklist

Analysis		(Y/N/X)	Notes:
8	Has the landslide mode of failure been determined?	Y	
	Check those that apply:		
	rotational failure		
	translational	✓	
	block failure		
	sheet		
	surface sloughing		
	slump		
	other (describe other failure modes)		
9	Have the subsurface conditions been identified which are the expected source of the failure mode?	Y	
	Check those that apply:		
	general shear strength failure of foundation soils		
	loading		
	along sloped rock surfaces		
	erosion		
	through thin, weak soil layers	✓	
	permeable materials		
	surface / groundwater		
	structure		
	Anthropogenic disturbances		
	weathering		
	impeded drainage		
	other (describe other sources)		
10	If water (static or flowing) significantly influences the stability of the landslide, has the source of water been identified, quantified, and water quality assessed?	X	Water does not appear to significantly influence stability.
11	Have calculations been performed to determine the F.S. for stability? Indicate which program and which analysis method (Spencer, Bishop, etc) was used.	N	
12	Have the following F.S. been met or exceeded, as determined by the calculations, for the given stability conditions:	X	
a.	1.30 for short term (undrained) condition		
b.	1.30 for long term (drained) condition		
c.	1.10 for rapid drawdown, flood condition		
d.	1.50 for slope containing or supporting a structural element		

V.A. Landslide Remediation Checklist

Analysis		(Y/N/X)	Notes:
13	When differing soil or loading conditions occur throughout the landslide area, have sufficient analyses been completed to evaluate the stability at locations representative of the most critical conditions?	Y	

Design		(Y/N/X)	Notes:
14	Has a landslide remediation method been determined?	Y	
	If yes, check the methods that were evaluated and note the chosen remediation:		
	benching and regrading (See GDM 800)		
	counter berm and regrading		
	flatten slope		
	geosynthetic reinforced slope		
	install surface / subsurface drainage system		
	shear key (See GDM 800)		
	soil nails or tiebacks		
	walls, sheeting, or drilled shafts	✓	
	soil anchoring		
	relocate existing alignments		
	lightweight fills		
	soil removal / treatment		
	chemical treatment		
	Bioengineering		
	other (describe other methods)		
15	Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, were calculations performed to evaluate the effectiveness of the chosen solutions?	Y	
16	Has a cost comparison been performed to evaluate a recommended solution compared to others?	N	

V.A. Landslide Remediation Checklist

Plans and Contract Documents		(Y/N/X)	Notes:
17	Have all necessary notes, specifications, and plan details been developed?	N	Plans will be provided at later date.
18	Has the vertical and lateral extent of defined landslide conditions been included on the Cross Sections and Plan and Profile sheets?	Y	
19	Has the information obtained from the exploration and analysis been incorporated into the project design?	Y	
20	Have the need, location, plan notes, and monitoring schedule of instrumentation been determined?	N	Monitoring likely not needed.
21	Have the effects of the stability solution on the construction schedule and maintenance of traffic been accounted for in the plans?	X	Plans will be provided at later date.
22	Have the effects of the original failure and proposed remediation on any structures (e.g., bridges, buildings, culverts, utilities) or adjacent properties been evaluated and solutions to any issues incorporated into final design?	N	No structures near site.

VI.A. Geotechnical Profile Checklist

C-R-S: JAC-35-15.36	**PID:** 116242	**Reviewer:** James Samples	**Date:** 1/11/2024

General Presentation		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Have the cadd files been prepared using the appropriate version of the ODOT CADD standards?	Y	
3	Has the geotechnical specification (title and date) under which the work was performed been clearly identified on every submission (reports, plans, etc.)?	Y	
4	Has the first complete version of all documents being submitted been labeled as 'Draft'?	Y	
5	Subsequent to ODOT's review and approval, has the complete version of the revised documents being submitted been labeled as 'Final'?	X	Drawing in draft stage
a.	Have the C-R-S, PID number, and product title been included in the folder name?	Y	
6	If the project includes structures, have all structure explorations been presented together under the same cover sheet? (Do not create separate Geotechnical Profile - Bridge Sheets)	Y	
7	Has a scale of 1"=1' been used for cover sheets, laboratory test data sheets, and boring log sheets, if applicable?	Y	
8	Based on the project length, has the correct horizontal scale been used to plot the project data?	Y	
	Check scale used:		
	1" = 5', 10', 20', 25', 40', or 50' for projects 1500' or less (use largest scale appropriate to present entire plan on one sheet)	✓	
	1" = 50' projects greater than 1500'		
9	Has a scale of 1" = 10' been utilized for the vertical scale of the project data?	Y	
10	If the project includes structures, has the plan and profile view been shown at the same scale as the Site Plan for the proposed structure(s), when possible?	Y	

VI.A. Geotechnical Profile Checklist

General Presentation	(Y/N/X)	Notes:
11 If the project includes culverts, have the plan and profile been presented along the flowline of the culvert?	X	
12 Have the cross-sections been plotted at a scale of 1" = 10' (preferred) or 1" = 20' (for higher or wider slopes)?	X	
Cover Sheet	(Y/N/X)	Notes:
13 Has the following general information been provided on the cover sheet:	Y	
a. Brief description of the project, including the bridge number of each bridge involved in the plan set, if any?	Y	
b. Brief description of historic geotechnical explorations referenced in this exploration? State if no historic records are available.	Y	
c. Generalized information about the geology of the project area, including terrain, soil origin, bedrock types, and age?	Y	
d. Brief presentation of geological and topographical information derived from the field reconnaissance? Include comments on structure and pavement conditions.	Y	
e. Brief presentation of test boring and sampling methods? Include date of last calibration and drill rod energy ratio as a percent for the hammer systems used.	Y	
f. Summary of general soil, bedrock, and groundwater conditions, including a generalized interpretation of findings?	Y	
g. A statement of which version (date) of the SGE specification the exploration was performed in accordance with?	Y	
h. Statement of where geotechnical reports are available for review?	Y	
i. Initials of personnel and dates they performed field reconnaissance, subsurface exploration and preparation of the geotechnical profile?	Y	

VI.A. Geotechnical Profile Checklist

Cover Sheet		(Y/N/X)	Notes:
14	Has a Legend been provided?	Y	
15	Have the following items been included in the Legend:	Y	
a.	Symbols and usual descriptions for only the soil and bedrock types presented in the Geotechnical Profile, as per the Soil and Rock Symbology Chart in Appendix D of the SGE?	Y	
b.	All miscellaneous symbols and acronyms, used on any of the sheets, defined?	Y	
c.	The number of soil samples for each classification that were mechanically classified and visually described in the current exploration?	Y	
16	Has a Location Map, showing the beginning and end stations for the project, been shown on the cover sheet, sized per the L&D3 Manual?	Y	
17	Have the station limits for each plan and profile sheet for projects with multiple alignments, or greater than 1500’, been identified in a table?	Y	
18	Have the station limits for any cross section sheets been identified in the same table?	Y	
19	Has a list of any structures for which structure foundation explorations been performed been identified in the same table?	Y	
20	If sampling and testing for a scour analysis was performed, has this data been shown in tabular form?	X	
21	Has a summary table of test data for all roadway and subgrade boring samples been shown?	X	
22	If borings from previous subsurface explorations are being used, has that data been shown in a separate table?	Y	
23	In the summary table, has the data been displayed by roadway and subgrade boring in ascending stationing order for each roadway?	X	
24	Have the centerline or baseline station, offset, and exploration identification number been provided for each boring presented in the table?	Y	

VI.A. Geotechnical Profile Checklist

Cover Sheet		(Y/N/X)	Notes:
25	For each sample, has the following information been provided in the summary table:	Y	
a.	Sample depth interval?	Y	
b.	Sample number and type?	Y	
c.	N_{60}?	Y	
d.	Percent recovery?	Y	
e.	Hand Penetrometer?	Y	
f.	Percentage of aggregate, coarse sand, fine sand, silt, and clay size particles?	Y	
g.	Liquid limit, plastic limit, plasticity index, and water content, all rounded to the nearest percent or whole number?	Y	
h.	ODOT classification and Group Index?	Y	
i.	Visual description of samples not mechanically classified, including water content, and estimated ODOT classification with 'Visual' in parentheses?	Y	
j.	Sulfate Content test results?	X	
26	Have all undisturbed test results been displayed in graphical format on the sheet prior to the plan and profile sheets?	Y	
Surface Data		(Y/N/X)	Notes:
27	Has the following information been shown on each roadway plan drawing:	Y	
a.	Existing surface features described in Section 702.5.1?	Y	
b.	Proposed construction items, as described in Section 702.5.2?	Y	
c.	Project and historic boring locations, with appropriate exploration targets and exploration identification numbers?	Y	
d.	Notes regarding observations not readily shown by drawings?	Y	
28	Have the existing ground surface contours been presented?	Y	
29	If cross sections are to be developed for stationing covered on a plan sheet, has an index for the appropriate cross section sheets been included on the plan sheet?	Y	

VI.A. Geotechnical Profile Checklist

Subsurface Data		(Y/N/X)	Notes:
30	Has all the subsurface data been presented in the form of a profile along the centerline or baseline, and on cross sections where applicable?	Y	
31	Have the graphical boring logs been correctly shown, as follows:	Y	
a.	Location and depth of boring indicated by a heavy dashed vertical line?	Y	
b.	Exploration identification number above the boring?	Y	
c.	Logs indicate soil and bedrock layers with symbols 0.4” wide and centered on the heavy dashed vertical line where possible?	Y	
d.	Bedrock exposures with 0.4” wide symbols, but without a heavy dashed vertical line?	Y	
e.	Soil and bedrock symbols as per ODOT Soil and Rock Symbology chart (SGE - Appendix D)?	Y	
f.	Historical borings shown in same manner with the exploration identification number above the boring?	Y	
32	Have the proposed groundline and existing groundline been shown on the profile view, according to ODOT CADD standards?	Y	
33	Have the locations of the proposed structure foundation elements been shown on the profile view?	Y	
34	Have the offsets from centerline or baseline been indicated above the borings in the profile view?	Y	
35	Have borings located immediately adjacent to the centerline or baseline and considered representative of centerline or baseline subsurface conditions been referenced directly to the centerline or baseline?	Y	
36	Have offset borings in or near the same elevation interval of a centerline or baseline boring been plotted either on a cross section or immediately above or below the centerline boring in a box containing an elevation scale?	Y	
37	Have cross-sections been developed to show subsurface conditions disclosed by a series of borings drilled transverse to centerline or baseline?	Y	

VI.A. Geotechnical Profile Checklist

Subsurface Data		(Y/N/X)	Notes:
38	Have the existing and proposed groundlines been displayed on cross section sheets according to ODOT CADD standards?	Y	
39	Have bedrock exposures shown on the cross sections been plotted along the contour of the cross section?	X	
40	Has the following information been provided adjacent to the graphical logs or bedrock exposure:	Y	
a.	Thickness, to the nearest inch, of sod/topsoil or other shallow surface material written above the boring (with corresponding symbology at top of log)?	Y	
b.	Moisture content, to nearest whole percent, with the bottom of the text aligned with the bottom of the sample? Label this column as 'WC' at bottom of the boring.	Y	
c.	N_{60}, aligned with the bottom of sample? Label column as 'N_{60}' at bottom of boring.	Y	
d.	Free water indicated by a horizontal line with a 'w' attached, and water level at the end of drilling indicated by an open equilateral triangle, point down?	Y	
e.	Complete geologic description of each bedrock unit, including unit core loss, unit RQD, SDI, and compressive strength test results? (Do not present geologic descriptions for structure borings for which this information is presented on the boring logs as described in 703.3)	Y	
f.	Visual description of any uncontrolled fill or interval not adequately defined by a graphical symbol?	Y	
g.	Organic content with modifiers, per 603.5?	X	
h.	Designate a plastic soil with moisture content equal to or greater than the liquid limit minus three with a 1/8" solid black circle adjacent to the moisture content?	X	
i.	Designate a non-plastic soil with moisture content exceeding 25% or exceeding 19% but appearing wet initially, with a 1/8" open circle with a horizontal line through it adjacent to the moisture content?	X	
j.	The reason for discontinuing a boring prior to reaching the planned depth indicated immediately below the boring?	X	

VI.A. Geotechnical Profile Checklist

Boring Logs		(Y/N/X)	Notes:
41	Have the boring logs of all structure borings, all geohazard borings, and any roadway borings drilled in the vicinity of the structures or geohazard been shown on the boring log sheets following the plan and profile sheets? (Create the logs in accordance with 703.3)	Y	
42	Have the boring logs been developed by integrating the driller's field logs, laboratory test data, and visual descriptions?	Y	
43	Has the following boring information been included in the heading of each boring log:	Y	
a.	Exploration identification number?	Y	
b.	Project designation (C-R-S) and PID?	Y	
c.	Structure File Number (if applicable) and project type?	X	
d.	Centerline or baseline name, station, offset, and surface elevation?	Y	
e.	Coordinates?	Y	
f.	Method of drilling?	Y	
g.	Date started and date completed?	Y	
h.	Method and material (including quantity) used for backfilling or sealing, including type of instrumentation, if any (reported in the footer)?	Y	
i.	Date of last calibration and drill rod energy ratio (ER) in percent for the hammer system(s) used, not to exceed 90%?	Y	
44	Has the following boring information been included in each boring log:	Y	
a.	A depth and elevation scale?	Y	
b.	Indication of stratum change?	Y	
c.	Description of material in each stratum?	Y	
d.	Depth of bottom of boring?	Y	
e.	Depth of boulders or cobbles, if encountered?	X	
f.	Caving depth?	X	
g.	Water level observations?	Y	
h.	Artesian water level and height of rise?	X	
i.	Heaving sand?	X	
j.	Cavities or other unusual conditions?	X	
k.	Depth interval represented by sample?	Y	
l.	Sample number and type?	Y	
m.	Percent recovery for each sample?	Y	
n.	Measured blow counts for each 6 inches of drive for split spoon samples, not to exceed 18 inches total?	Y	
o.	N_{60} to the nearest whole number?	Y	

VI.A. Geotechnical Profile Checklist

p. Hand penetrometer?	Y	

VI.A. Geotechnical Profile Checklist

Boring Logs		(Y/N/X)	Notes:
q.	Particle-size analysis?	Y	
r.	Liquid limit, plastic limit, plasticity index?	Y	
s.	Water content?	Y	
t.	ODOT soil classifications, with "V" in parentheses for those samples that are not mechanically classified?	Y	
u.	Top of bedrock and bedrock descriptions?	Y	
v.	Rock core run percent recovery?	Y	
w.	Run RQD?	Y	
x.	Unit rock core percent recovery?	Y	
y.	Unit RQD?	Y	
z.	SDI, if applicable?	X	
aa.	Rock compressive strength test results, if applicable?	Y	

VI.B. Geotechnical Reports

C-R-S: JAC-35-15.36	PID: 116242	Reviewer: James Samples	Date: 1/11/2024

General		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'?	Y	
3	Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'?	Y	
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files meet this demand?	Y	
5	Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ?	Y	
6	Have all geotechnical reports being submitted been titled correctly as prescribed in Section 706.1 of the SGE?	Y	
Report Body		(Y/N/X)	Notes:
7	Do all geotechnical reports being submitted contain the following:	Y	
a.	an Executive Summary as described in Section 706.2 of the SGE?	Y	
b.	an Introduction as described in Section 706.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 706.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 706.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 706.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 706.7 of the SGE?	Y	
Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 706.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 706.8.1 of the SGE?	Y	

VI.B. Geotechnical Reports

Appendices		(Y/N/X)	Notes:
10	Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 706.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 706.8.3 of the SGE?	Y	
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 706.8.4 of the SGE?	Y	